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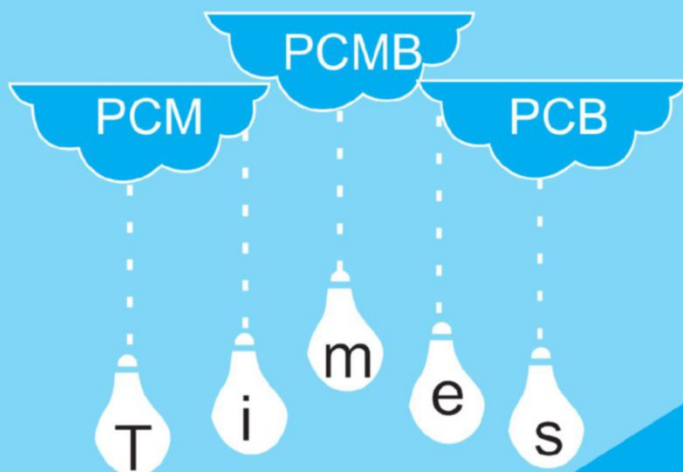
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Quantitative Treatment of Acid - Base Equilibria

Concept of the month

This column is aimed at preparing students for all competitive exams like JEE, NEET, BITSAT etc. Every concept has been designed by highly qualified faculty to cater to the needs of the students by discussing the most complicated and confusing concepts in Chemistry.

By: P. BRAHMA REDDY
(Alumni from IIT Delhi)

Introduction

Different concepts have been put forth by different investigators to characterise acids and bases. While some of the concepts are quite narrow in their approach, others are fairly comprehensive. Some important concepts of acids and bases are given below.

Arrhenius concept

- An **Acid** is a substance that dissociates to give **hydrogen ions**(H^+) when dissolved in water
- A **base** is a substance which dissociates into **hydroxyl ions**(OH^-) when dissolved in water.

Proton Transfer Theory (Concept of Lowry & Bronsted)

- An **Acid** is a proton (H^+) donor.
 $Acid \rightarrow H^+ + conjugate\ base$
- A **base** is a proton (H^+) acceptor
 $Base + H^+ \rightarrow conjugate\ acid$

The Lewis Concept

- An **acid** is a species that is capable of accepting a pair of electrons to form a covalent bond.
- A **base** is a species that is capable of donating a pair of electrons to form a covalent bond.

Quantitative treatment of acid - base equilibria of Strong acids - bases

- Strong acid and strong base is one that is completely ionized in aqueous solution.
- HCl , HNO_3 , HI or $HClO_4$ are the common examples

of strong acids and $NaOH$, KOH , $Ba(OH)_2$ etc are the common examples of strong bases.

- When HCl (a strong acid) gas is dissolved in water, the resulting solution contains the ions H^+ (or H_3O^+), OH^- or Cl^- , but except for very concentrated solution, the concentration of unionized acid ' HCl ' is negligible and for all practical purposes, molecules of HCl don't exist in their dilute aqueous solutions.

- In order to specify the concentrations of three species present in the aqueous solution of HCl , we need three independent relations between them given below

- (1) The dissociation equilibrium of water must always be satisfied

$$[H^+][OH^-] = K_w = 10^{-14} \text{ at } 25^\circ C$$

- (2) For any acid base system, one can write a mass balance equation that relates the concentration of various species as in case of HCl .

$$HCl + Cl^- = C_a, \text{ where } C_a \text{ is a nominal conc.}$$

of the substance initially taken

But since HCl is a strong acid, we can neglect the first term and write the trivial mass -balance equation.

$$[Cl^-] = C_a$$

- (3) Must satisfy electro-neutrality principle

$$[H^+] = [OH^-] + [Cl^-]$$

In case of pure acid solution $[OH^-]$ remains negligibly small compared to the concentration of

anion from acid (conjugate base), otherwise, the above equation is converted into single variable equation and solved as

$$[H^+] = C_a + \frac{K_w}{[H^+]}$$

As long as the solution is not very dilute,

$$[H^+] = C_a$$

As the concentration falls below about 10^{-6} M,

$$[H^+] = C_a + \frac{K_w}{[H^+]}$$

Activity and analytical concentrations

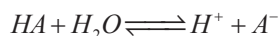
- In more concentrated solutions of either acids or bases, the interaction between the ions causes their effective concentration known as their activities to deviate from their analytical concentrations.
- The relation between the concentration of a species and its activity is expressed by the activity coefficient γ :

$$a = \gamma C$$

- As a solution becomes more dilute ' γ ' approaches unity
- As ion concentrations below 0.001M, the concentration can generally be used in place of activity with negligible error.
- Also, pH is defined as the negative logarithm of the hydrogen ion activity, not its concentration.

Quantitative treatment of acid - base equilibria of Weak acids - bases

Let us consider an acid HA which when dissolved in water, an equilibrium will setup between ionised and unionised acid molecule as below



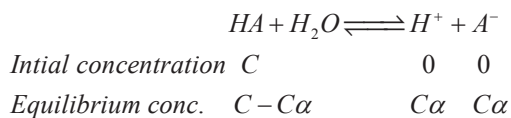
On applying the law of mass action, the equilibrium constant K is written as

$$K = \frac{[H^+][A^-]}{[HA][H_2O]}$$

$$K[H_2O] = K_a = \frac{[H^+][A^-]}{[HA]}$$

where ' K_a ' is the characteristic of the individual acid

Assume that the initial concentration is C moles/lit. and ' α ' is the degree of ionization then



$$K_a = \frac{C\alpha \times C\alpha}{C(1-\alpha)} = \frac{\alpha^2 C}{(1-\alpha)}$$

The degree of ionisation ' α ' is very small ($\alpha \ll 1$) So, $1 - \alpha = 1$

$$\text{Thus, } K_a = \alpha^2 C; \alpha^2 = \frac{K_a}{C}$$

$$\text{or } \alpha = \sqrt{\frac{K_a}{C}}$$

$$\frac{1}{C} = V$$

$$\text{So, } \alpha = \sqrt{K_a \times V}$$

This equation is known as ostwald dilution law equation.

Similarly, for a weak base we have

$$\alpha = \sqrt{\frac{K_b}{C}}$$

$$\frac{1}{C} = V$$

$$\text{So, } \alpha = \sqrt{K_b \times V}$$

Where,

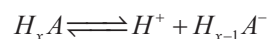
K_b is the dissociation constant of weak base.

C is the initial concentration

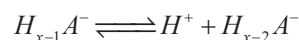
α is the degree of dissociation of weak base.

Diprotic and polyprotic acid

Diprotic / polyprotic acids undergo stepwise ionization when dissolved in water



$$K_{a_1} = \frac{[H^+][H_{x-1} A^-]}{[H_x A]}$$

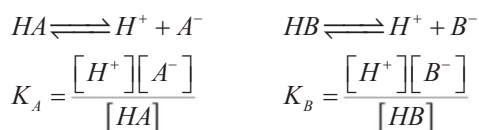


$$K_{a_x} = \frac{[H^+][H_{x-2}A^-]}{[H_{x-1}A^-]}$$

For most of the cases, $K_{a1} > K_{a2} \dots$ and in this situation, contribution of higher order ionization to the $[H^+]$ could be ignored.

Mixture of weak acids

Let us consider a mixture of two weak acids HA and HB solution. In solution, they will ionize as



Now applying the charge balance in the solution:

$$[H^+] = [A^-] + [B^-] + [OH^-]$$

$$= \frac{K_A[HA]}{[H^+]} + \frac{K_B[HB]}{[H^+]} + \frac{K_w}{[H^+]}$$

$$[H^+]^2 = K_A[HA] + K_B[HB] + K_w$$

If acid is neither very strong nor very dilute, we can replace equilibrium concentrations with nominal concentrations (initial concentrations).

$$[H^+] = \sqrt{K_A C_{HA} + K_B C_{HB} + K_w}$$

Exercise

IIT MAINS/NEET

(SINGLE OPTION CORRECT QUESTIONS)

- The pH of a 0.01M solution of a monobasic acid is four. Which one of the following statement about the acid is incorrect?
 - When a little NaOH is added, it will form a buffer solution
 - It is a weak acid
 - It's sodium salt will be acidic
 - It's sodium salt will be basic
- The dissociation constant of a monobasic acid which is 3.5% dissociated in N/20 solution at 20°C is
 - $3.5 \times 10^{-2} M$
 - $5 \times 10^{-3} M$
 - $6.125 \times 10^{-5} M$
 - $6.75 \times 10^{-2} M$
- Several acids are listed below with their respective equilibrium constants:

$$HF_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + F^-_{(aq)}; \quad K_a = 7.2 \times 10^{-4}$$

$$HS^-_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + S^{2-}_{(aq)}; \quad K_a = 1.3 \times 10^{-11}$$

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}; \quad K_a = 1.8 \times 10^{-5}$$
 Which is the strongest acid and which acid has the strongest conjugate base?
 - HF and HF
 - HF and HS^-
 - HS^- and CH_3COOH
 - HS^- and HF
- The pH of a solution of H_2O_2 is 6.0. Some chlorine gas is bubbled into this solution. Which of the following is correct?
 - hydrogen gas is liberated
 - The pH of resultant solution becomes 8.0
 - The pH of resultant solution becomes less than 6.0 and oxygen gas is liberated
 - Cl_2O is formed in the resultant solution
- The pH of a solution obtained by mixing 100 mL of a HCl solution of pH = 2 with 400 mL of another HCl solution of pH = 3 is
 - 3
 - 2.55
 - 1.55
 - 3.5
- The pH of a $10^{-7} M$ aqueous solution of KOH is
 - 7
 - 7.2
 - 7.1
 - 6.99
- A weak acid, HA, with an ionization constant of approximately 10^{-4} , is prepared in a 1molar aqueous solution. What will happen to the percent dissociation of this acid as more pure water is added to the solution?
 - Percent dissociation remains unchanged
 - Percent dissociation will increase
 - Percent dissociation will decrease
 - The ionization constant will increase
- What volume of a 0.1 M HCl solution should be added to a 500 mL of 0.5M formic acid solution in order to prepare an acid solution of pH 1.5, K_a of formic acid is 2×10^{-4} at 25°C?
 - 208 mL
 - 308 mL
 - 150 mL
 - 250 mL
- The pH of an aqueous solution of carbonic acid if molar solubility of CO_2 in the given condition is 0.01. $K_{a1} = 4.2 \times 10^{-7}$ and $K_{a2} = 4.8 \times 10^{-11}$.
 - 5
 - 5.18
 - 4.18
 - 4

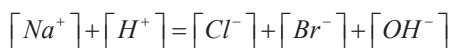
10. The pH of a solution containing 0.1 M acetic acid and 0.2 M phenol is (K_a of acetic acid is 2×10^{-5} and K_a of phenol is 10^{-10})
 (a) 1 (b) 2 (c) 2.15 (d) 2.85

ADVANCED LEVEL

11. Addition of 100 mL 0.1M HCl to a certain volume of slightly weak monobasic (0.1M) acid solution decreases its pH from 2.88 to 1.3. The volume of weak acid solution is
 (a) 100 mL (b) 150 mL (c) 500 mL (d) 300 mL
12. A 200 mL volume of NaOH solution was added to 400 mL of a 2M HNO_2 solution. The pH of the mixed solution was 1.5 units greater than that of original acid solution. The molarity of NaOH solution is ($K_a = 4 \times 10^{-4}$)
 (a) 1 M (b) 1.22 M (c) 1.5 M (d) 2 M
13. A student dissolved 0.100 mol of an unknown monoprotic acid, HA, in sufficient water to make 1 L of solution. She measured the pH of the solution as pH = 2.60. Of the following, the acid HA is
 (a) acetic acid, $K_a = 1.8 \times 10^{-5} M$
 (b) benzoic acid $K_a = 6.6 \times 10^{-5} M$
 (c) hypochlorous acid $K_a = 3.1 \times 10^{-8} M$
 (d) hydrofluoric acid $K_a = 3.5 \times 10^{-4} M$

(ONE OR MORE THAN ONE CORRECT OPTIONS)

14. For a solution, the charge balance equation is



The solution could be

- (a) NaCl/NaBr/NaI simultaneously
 (b) NaCl/NaBr/HBr/HI simultaneously
 (c) NaOH/HCl/HBr/HI simultaneously
 (d) NaI/HCl/HBr/HI simultaneously
15. Ionization constants (K_a) for three weak monobasic acids HA, HB and HD are 10^{-5} , 10^{-7} and 10^{-9} respectively at 25°C. Which of the following is/are correct deduction?
 (a) $(pH)_{NaA} < (pH)_{NaB}$
 (b) $(pH)_{NaD} < (pH)_{NaB}$
 (c) $(pH)_{NaA} < (pH)_{NaD}$
 (d) $(pH)_{NaB} = 7$

MATCH THE FOLLOWING

16. Column I

- A. CCl_4
 B. AlCl_3
 C. NH_3
 D. HClO_4

Column II

- (p) Lewis acid
 (q) Lewis base
 (r) Bronsted acid
 (s) Bronsted base
 (t) Neither lewis acid nor lewis base

SUBJECTIVE TYPE QUESTIONS

17. What is the pH of a 1.0M solution of acetic acid? To what volume of one litre of this solution be diluted so that the pH of the resulting solution will be twice the original value? Given $K_a = 1.8 \times 10^{-5}$
18. The average concentration of SO_2 in the atmosphere over a city on a certain day is 10ppm, when the average temperature is 298K. Given that the solubility of SO_2 in water at 298K is 1.3653 mol L^{-1} and the pK_a of H_2SO_3 is 1.92, estimate the pH of rain on that day.
19. The first ionization constant of H_2S is 9.1×10^{-8} . Calculate the concentration of HS^- ion in its 0.1M solution and how will this concentration be effected if the solution is 0.1M in HCl also. If the second dissociation constant of H_2S is 1.2×10^{-13} , calculate the concentration of S^{2-} under both conditions.
20. A certain acid - base indicator is red in acid and blue in basic solution. At pH=5, 75% of the indicator is present in the solution in its blue form. Calculate dissociation constant (K_a) for the indicator and pH range over which the indicator changes from 90% red - 10% blue to 90% blue - 10% red.

ANSWER KEY

1. (c) 2. (c) 3. (b) 4. (c)
 5. (b) 6. (b) 7. (b) 8. (a)
 9. (c) 10. (d) 11. (a) 12. (b)
 13. (b) 14. (a), (b), (d) 15. (a), (c)
 16. A-(t), B-(p), C-(q,r,s), D-(r)

HINTS & SOLUTIONS

1. Sol: Concentration of monobasic acid = 0.01 M and pH = 4

If the acid is completely ionised the pH of the acid would be

$$\text{pH} = -\log 0.01 = -\log 10^{-2} = 2$$

So it is a weak acid. The sodium salt of a weak acid when dissolved the anions will be hydrolysed giving rise to OH^- ion concentration. The solution will be basic.

2.Sol:

$$\text{Concentration of acid} = \frac{N}{20} = 0.05N$$

20 Out of 100 molecules, 3.5 molecules have been dissociated

Out of 1 molecules the no. of dissociated molecules

$$= \frac{3.5}{100} = 0.035 = \alpha$$

$$K_a = \frac{C\alpha^2}{(1-\alpha)}, \quad K_a = \alpha^2 C$$

$$K_a = \frac{0.035 \times 0.035 \times 1}{20}$$

$$K_a = 6.125 \times 10^{-5}$$

3.Sol: Higher is the value of K_a , stronger is the acids. Hence, here, HF is the strongest acid while HS^- is the weakest. Weakest acid (HS^-) has the strongest conjugate base.

4.Sol: $\text{H}_2\text{O}_2 + \text{Cl}_2 \rightarrow 2\text{HCl} + \text{O}_2$

As HCl (a strong acid) is produced, hence $[\text{H}^+]$ of the solution increases, pH of the solution decreases.

5.Sol:

$$\text{Solution I, pH} = 2 \therefore [\text{H}^+] = 10^{-2}$$

$$\text{mmol of } \text{H}^+ = 100 \times 10^{-2} = 1$$

$$\text{Solution II, pH} = 3 \therefore [\text{H}^+] = 10^{-3}$$

$$\text{mmol of } \text{H}^+ = 400 \times 10^{-3} = 0.4$$

$$\text{Total mmol of } \text{H}^+ = 1.4$$

$$\text{And total volume} = 100 + 400 = 500$$

$$[\text{H}^+]_{\text{final}} = \frac{1.4}{500} = 2.8 \times 10^{-3}$$

$$\text{pH} = -\log(2.8 \times 10^{-3}) = 2.55$$

6.Sol: It is a case of very dilute solution of strong base, contribution of $[\text{OH}^-]$ from the ionization of

water will have to be considered. Now applying the concept of electro-neutrality.

$$[\text{OH}^-] = [\text{K}^+] + [\text{H}^+] = 10^{-7} + \frac{K_w}{[\text{OH}^-]}$$

$$[\text{OH}^-]^2 - 10^{-7} [\text{OH}^-] - 10^{-14} = 0$$

$$\text{On solving, } [\text{OH}^-] = 1.6 \times 10^{-7}$$

$$\text{pOH} = 7 - \log 1.6 = 6.8$$

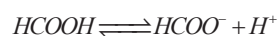
$$\text{pH} = 7.2$$

7.Sol: Degree of dissociation of weak acid increases upon dilution

8.Sol: Let V mL of HCl be added to get the desired solution

$$\text{Now, total volume of solution} = 500 + V$$

$$\text{mmol of HCl added} = 0.1V$$



Initial mmol	250	0.1V (from HCl)
At Equilibrium	250 - x	x

$$K_a = \frac{[\text{H}^+][\text{HCOO}^-]}{[\text{HCOOH}]} = 2 \times 10^{-4}$$

$$\text{Also, } [\text{H}^+]_{\text{final}} = 10^{-1.5} \text{ M} = 0.0316 \text{ M}$$

$$2 \times 10^{-4} = \frac{0.0316 \text{ M}}{250 - x} \Rightarrow x = 1.57 \text{ mmol}$$

$$\text{Also, } [\text{H}^+] = \frac{0.1V + x}{500 + V} = \frac{0.1V + 1.57}{500 + V} = 0.0316$$

$$V = 208 \text{ mL}$$

9. Sol: pH or $[\text{H}^+]$ will be determined considering only first ionization reaction of diprotic acid.

$$\text{So, } 4.2 \times 10^{-7} = \frac{[\text{H}^+]^2}{C}$$

$$[\text{H}^+] = \sqrt{4.2 \times 10^{-7} \times 10^{-2}}$$

$$\text{pH} = 4.18$$

10. Sol: Since both are very weak acids:

$$[\text{H}^+] = [2 \times 10^{-1.5} \times 0.1 + 10^{-10} \times 0.2 + 10^{-14}]^{1/2}$$

$$= 1.41 \times 10^{-3} \text{ M}$$

$$\text{pH} = 2.85$$

Here, neither phenol nor water any significant contribution to the total H^+ concentration and pH is mainly due to acetic acid.

11. Sol:

Before addition of HCl:

$$K_a \text{ of } HA = \frac{C\alpha^2}{1-\alpha}$$

Also; pH = 2.88

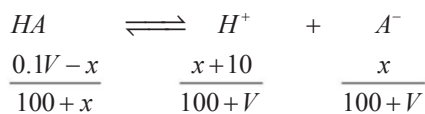
$$[H^+] = 1.31 \times 10^{-3} = C\alpha$$

$$\alpha = 1.31 \times 10^{-2}$$

$$K_a = \frac{(C\alpha)\alpha}{1-\alpha} = \frac{1.31 \times 10^{-3} \times 1.31 \times 10^{-2}}{1-1.31 \times 10^{-2}} = 1.7 \times 10^{-5}$$

Also, α is very small even in absence of HCl, addition of HCl will further decrease α and it can be ignored.

Also; let there be V mL of weak acid.

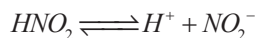


$$K_a = 1.7 \times 10^{-5} = \frac{(x+10)x}{(0.1V-x)(V+100)}$$

$$\text{and } [H^+] = \frac{x+10}{100+V} = 5 \times 10^{-5}$$

Solving for V gives as, V = 100 mL

12. Sol:



$$K_a = 4 \times 10^{-4} = \frac{[H^+]^2}{C}$$

$$[H^+] = 0.028M$$

$$pH = 1.54M$$

After addition of NaOH, pH = 1.54 + 1.5 = 3.04

$$[H^+] = 9.12 \times 10^{-4} M$$

Also, let us assume that molarity of NaOH = x mmol of HNO_2 left = 800 - 200x

$$K_a = \frac{[H^+][NO_2^-]}{[HNO_2]} \Rightarrow 4 \times 10^{-4} = \frac{9.12 \times 10^{-4} \times 200(x)}{800-x}$$

$$x = 1.22 M$$

15. Sol: Use K_a formula

$$\begin{aligned} \text{17. Sol: As degree of dissociation } (\alpha) &= \sqrt{K_a / C} \\ &= \sqrt{(1.8 \times 10^{-5} / 1)} \\ &= 4.2426 \times 10^{-3} \end{aligned}$$

$$[H^+] = C \times \alpha$$

$$= 1 \times 4.2426 \times 10^{-3}$$

$$= 4.2426 \times 10^{-3} \text{ molL}^{-1}$$

$$pH = -\log_{10} [H^+]$$

$$= -\log_{10} 4.2426 \times 10^{-3}$$

$$= 2.3724$$

So pH of the acetic acid solution after dilution

$$= 2 \times 2.3724 = 4.7448$$

$$\text{New } [H^+] = 10^{-4.7448} = 1.8 \times 10^{-5}$$

Suppose the new concentration is C_0 .



$$\text{At eq. } C_0 - 1.8 \times 10^{-5} \quad 1.8 \times 10^{-5} \quad 1.8 \times 10^{-5}$$

$$\text{As } K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$$

$$= \frac{1.8 \times 10^{-5} \times 1.8 \times 10^{-5}}{(C_0 - 1.8 \times 10^{-5})} = 1.8 \times 10^{-5}$$

$$\text{So } C_0 = 3.6 \times 10^{-5}$$

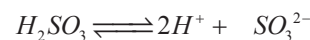
Suppose the new volume is V litre

$$1 \times 1 = 3.6 \times 10^{-5} \times V$$

$$V = \frac{1}{3.6 \times 10^{-5}} = 2.78 \times 10^4 \text{ litre}$$

18. Sol: $pK_a = 1.92$

$$K_a = \text{Anti log}(-1.92) = 0.012$$



$$t=0 \quad C \quad 0 \quad 0$$

$$t_{eq} \quad C-C\alpha \quad 2C\alpha \quad C\alpha$$

$$K_a = \frac{[H^+]^2 [SO_3^{2-}]}{[H_2SO_3]}$$

$$0.012 = \frac{(2C\alpha)^2 \times C\alpha}{C(1-\alpha)} = \frac{4C^2\alpha^3}{(1-\alpha)} = 4C^2\alpha^3$$

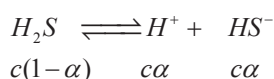
$$0.012 = 4 \times (1.3653)^2 \times \alpha^3$$

$$\alpha = 0.117$$

$$[H^+] = 2C\alpha = 2 \times 1.3653 \times 0.117 = 0.3194$$

$$pH = -\log_{10} 0.3194 = 0.495$$

19.Sol:



$$I. \quad K_{a_1} = 9.1 \times 10^{-8} = \frac{[H^+][HS^-]}{[H_2S]}$$

$$(\text{Given } [H_2S] = 0.1 = c)$$

$$9.1 \times 10^{-8} = \frac{c^2\alpha^2}{c(1-\alpha)} = c\alpha^2 \quad (\because 1-\alpha \approx 1)$$

$$9.1 \times 10^{-8} = 0.1 \times \alpha^2$$

$$\therefore \alpha = 9.54 \times 10^{-4}$$

$$[HS^-] = c\alpha = 0.1 \times 9.54 \times 10^{-4} = 9.54 \times 10^{-4} M$$

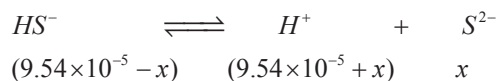
$$II. \text{ If } [H^+] = 0.1 \text{ then}$$

$$K_{a_1} = 9.1 \times 10^{-8} = \frac{[H^+][HS^-]}{[H_2S]} = \frac{0.1 \times c\alpha}{c} = 0.1 \times \alpha$$

$$\alpha = 9.1 \times 10^{-7}$$

$$[HS^-] = c\alpha = 0.1 \times 9.1 \times 10^{-7} = 9.1 \times 10^{-8} M$$

$[S^{2-}]$ in I Case:



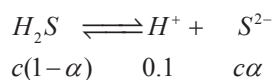
$$K_{a_2} = 1.2 \times 10^{-13} = \frac{[H^+][S^{2-}]}{[HS^-]} = \frac{(9.54 \times 10^{-5} + x) \cdot x}{(9.54 \times 10^{-5} - x)}$$

$$\text{or } x = K_{a_2}$$

(x is very very small due to common ion effect)

$$[S^{2-}] = 1.2 \times 10^{-13} M$$

$[S^{2-}]$ in II Case:



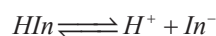
$$K_{a_1} \times K_{a_2} = \frac{[H^+]^2[S^{2-}]}{[H_2S]} = \frac{(0.1)^2 \times c\alpha}{c(1-\alpha)}$$

$$\alpha = \frac{9.1 \times 10^{-8} \times 1.2 \times 10^{-13}}{10^{-2}} = 10.92 \times 10^{-19}$$

$$[S^{2-}] = c\alpha = 0.1 \times 10.92 \times 10^{-19}$$

$$= 1.092 \times 10^{-19} = 1.092 \times 10^{-19} M$$

20.Sol: Since K_a is asked, the indicator must be acid. Let the acid be represented by HIn.



In acid solution, the indicator will be predominately present in the form of HIn (due to common ion effect). Since in acid solution the colour is red, this would be due to HIn. In basic solution, the indicator will be predominately in the form of In^- . Since the indicator is blue in basic solution, so In^- must be blue in colour.

At pH=5, the indicator is 75% blue. This also means it is 25% red.

$$\therefore K_a = \frac{10^{-5} \times 0.75}{0.25} = 3 \times 10^{-5}$$

pH when it is 90% red and 10% blue:

$$[H^+] = \frac{K_a \times [HIn]}{[In^-]} = \frac{3 \times 10^{-5} \times 0.9}{0.1} = 2.7 \times 10^{-4}$$

$$\therefore \text{pH} = 3.56$$

pH when it is 90% blue and 10% red:

$$[H^+] = \frac{K_a \times [HIn]}{[In^-]} = \frac{3 \times 10^{-5} \times 0.1}{0.9} = 3.3 \times 10^{-6}$$

GLIMPSE OF ELITE SERIES

BENZENE DIAZONIUM CHLORIDE

- When benzenediazonium chloride is heated with fluoro boric acid, fluorobenzene is formed. This reaction is called
 (a) Hoffmann bromamide reaction
 (b) Balz schiemann reaction
 (c) Gattermann reaction
 (d) Sandmeyer reaction

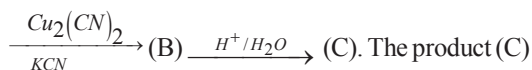
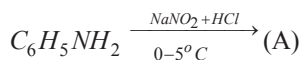
- Benzene diazonium chloride is the product when aniline is treated with
 (a) NaNO_2 and HCl at $0-5^\circ\text{C}$
 (b) HNO_3 and HCl at 4°C
 (c) $\text{C}_6\text{H}_5\text{NO}_2$ at 4°C
 (d) NaNO_2 at 4°C

- $\text{C}_6\text{H}_5\text{Cl} \xrightarrow[\text{Cu}_2\text{O}, 200^\circ\text{C}]{\text{NH}_3} \text{X}$;
 $\text{X} \xrightarrow[0-5^\circ\text{C}]{\text{HNO}_2} \text{Z}$; $\text{X} + \text{Z} \rightarrow \text{A}$; the no. of σ and π bonds in 'A' are
 (a) $25\sigma, 6\pi$ (b) $25\sigma, 7\pi$
 (c) $27\sigma, 7\pi$ (d) $27\sigma, 6\pi$

- $\text{CaC}_2 \xrightarrow[\text{-Ca(OH)}_2]{\text{Hydrolysis}} \text{A} \xrightarrow[\text{Fe tube}]{\text{Redhot}} \text{B}$
 $\xrightarrow[50-60^\circ\text{C}]{\text{HNO}_3 + \text{H}_2\text{SO}_4} \text{C}$
 $\xrightarrow[\text{NaNO}_2 + \text{HCl}, 0^\circ\text{C}]{\text{Fe} + \text{HCl}} \text{D} \rightarrow \text{E}$

Then E is

- Aniline black
 - Benzene diazonium chloride
 - Phenyl osazone
 - Benzoyl chloride
- In the reaction,



is

- $\text{C}_6\text{H}_5\text{CH}_2\text{NH}_2$ (b) $\text{C}_6\text{H}_5\text{COOH}$
- $\text{C}_6\text{H}_5\text{OH}$ (d) all the above

- Which of the following statements is incorrect?

- $\text{C}_6\text{H}_5\text{N}_2\text{Cl}$ is soluble in water.
- $\text{C}_6\text{H}_5\text{N}_2\text{BF}_4$ is soluble in water.
- $\text{C}_6\text{H}_5\text{N}_2\text{Cl}$ is stable at room temperature.
- $\text{C}_6\text{H}_5\text{N}_2\text{Cl}$ is stable at 0°C .

- Which of the following converts Benzene diazonium chloride to Benzene?

- H_3PO_3 (b) $\text{C}_2\text{H}_5\text{OH}$
- H_2O (d) HBF_4

- Benzene diazonium chloride when reduced with sodium sulphite yields

- chlorobenzene
- benzene
- phenyl hydrazine chloride
- phenol

- During the preparation of arene diazonium salts, the excess of nitrous acid, if any, is destroyed by adding

- aq. NaOH (b) aq. Na_2CO_3
- aq. NH_2CONH_2 (d) aq. KI

- When benzene diazonium chloride is reacted with methanol, the product formed is

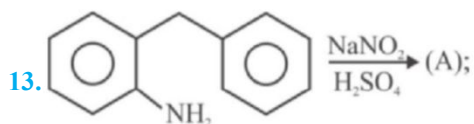
- benzene (b) benzenol
- benzyl alcohol (d) anisole

11. The main product of reduction of nitrobenzene with lithium aluminiumhydride is

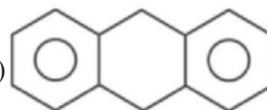
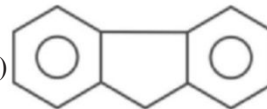


- (a) azoxybenzene (b) aniline
(c) azobenzene (d) diazonium salts

12. A primary nitroalkane is treated with nitrous acid, which of the following will be the main product?

- (a) Nitrolic acid (b) Pseudonitrol
(c) A primary amine (d) A primary alcohol



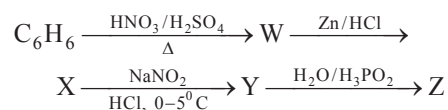
Product (A) of this reaction is

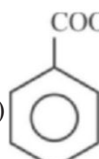

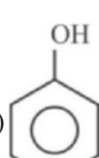

- (a) 
(b) 
(c) 
(d) 

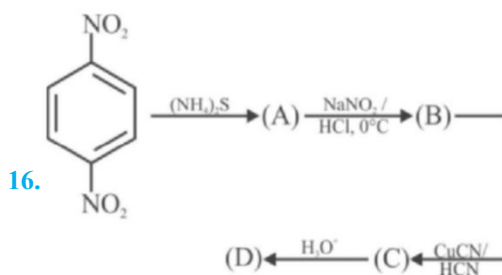
14. Benzene diazonium chloride on reaction with Phenol in presence of NaOH gives diphenyl. This reaction is known as

- (a) Sandmeyer's reaction
(b) Gomberg reaction
(c) Gattermann reaction
(d) Balz Schiemann reaction

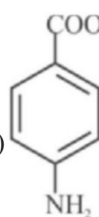
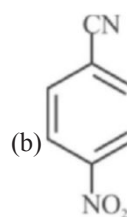
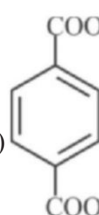
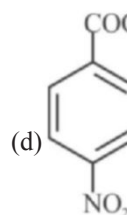
15. 'Z' in the following sequence of reaction is



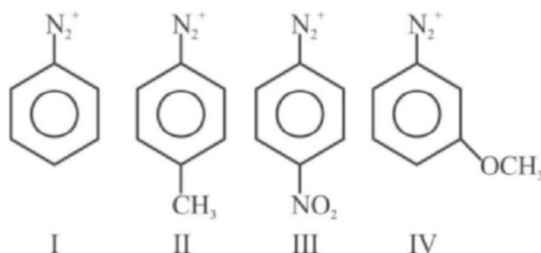
- (a)  (b) 
(c)  (d) 



The above reaction sequence (D) is

- (a)  (b) 
(c)  (d) 

17. Write the correct order of the following diazonium cations for the coupling with phenol



- (a) II > IV > I > III (b) III > I > II > IV
(c) III > IV > I > II (d) II > I > IV > III

18. In the diazotisation of arylamines with sodium nitrite and hydrochloric acid, an excess of hydrochloric acid is used primarily to

- (a) Suppress the concentration of free aniline available for coupling
(b) Suppress hydrolysis of phenol
(c) Ensure a stoichiometric amount of nitrous acid
(d) Neutralise the base liberated

19. The compound which on reaction with aqueous nitrous acid at low temperature produces an oily nitrosoamine is

- (a) methylamine (b) ethylamine
(c) diethylamine (d) triethylamine

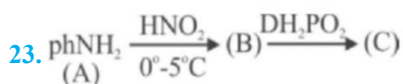
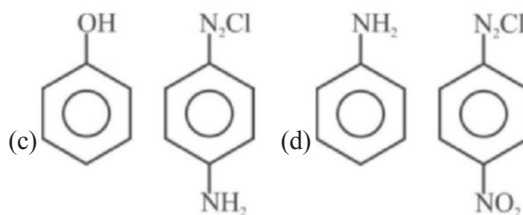
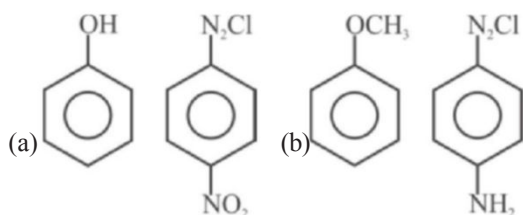
20. In laboratory, benzene diazonium chloride is not isolated in the crystalline solid state because in solid state it

- (a) explodes (b) is readily oxidised
(c) is readily reduced (d) is polymerised

21. Benzene diazonium chloride does not form orange red dye with

- (a) phenol (b) cresol
(c) resorcinol (d) aniline

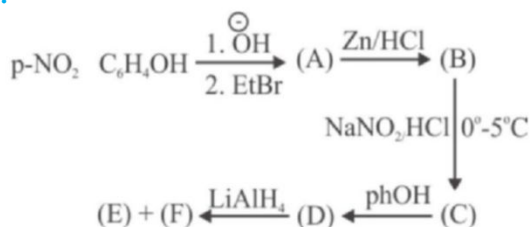
22. Which of the following pair make fastest coupling reaction in acidic medium?



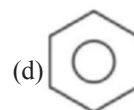
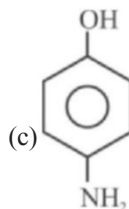
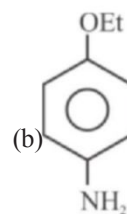
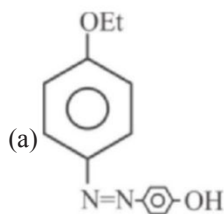
Identify compound (C).

- (a) PhOH (b) $\text{Ph} - \text{N}_2^+ \text{Cl}^-$
(c) $\text{C}_6\text{H}_5\text{D}$ (d) C_6H_6

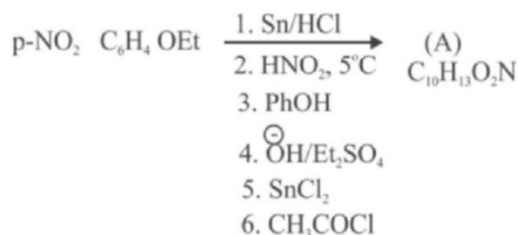
24.



Compound (F) dissolves in NaOH. Identify the compound (F).



25.



Compound (A) is a/an

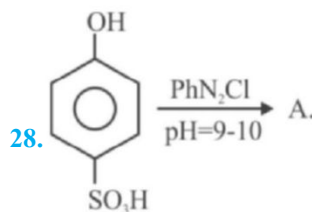
- (a) Analgesic (b) Antipyretic
(c) Both (a) & (b) (d) Antiseptic

26. Benzene diazonium chloride on reaction with $\text{K}_3[\text{Cu}(\text{CN})_4]$ produces

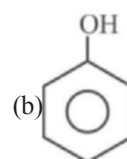
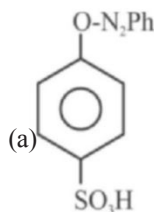
- (a) Benzene (b) Cyanobenzene
(c) Aniline (d) No product

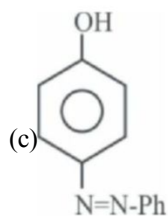
27. $\text{C}_6\text{H}_5\text{N}_2\text{Cl}$ on coupling with β -naphthol produces _____ color product (pH=9-10)

- (a) Orange dye (b) Yellow dye
(c) Black dye (d) Pink dye



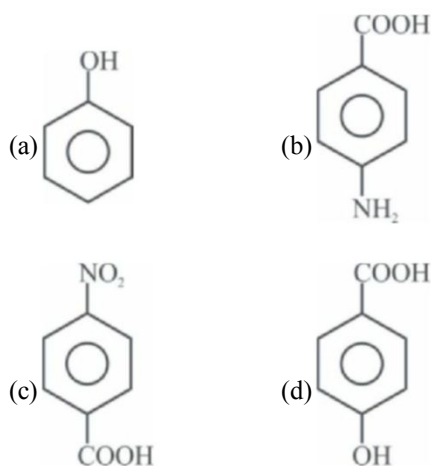
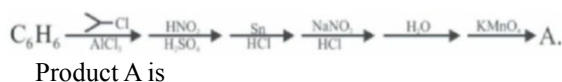
The product "A" is





(d) No reaction

29.



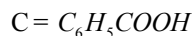
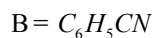
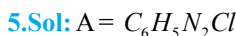
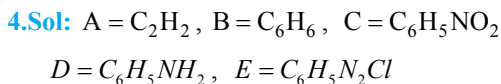
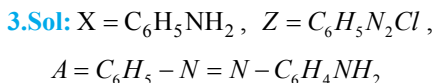
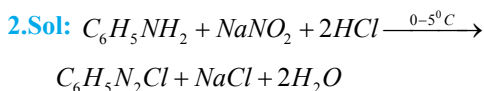
30. Which of the following is used to prepare methyl orange indicator?

- (a) Aniline
 (b) N, N-dimethylaniline
 (c) Derivative of benzene diazonium chloride
 (d) Both (b) & (c)

ANSWER KEY

- | | | | | |
|-------|-------|-------|-------|-------|
| 1. b | 2. a | 3. c | 4. b | 5. b |
| 6. c | 7. b | 8. c | 9. c | 10. a |
| 11. c | 12. a | 13. b | 14. b | 15. b |
| 16. d | 17. c | 18. a | 19. c | 20. a |
| 21. d | 22. d | 23. c | 24. c | 25. c |
| 26. b | 27. a | 28. c | 29. d | 30. d |

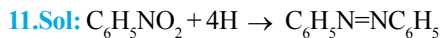
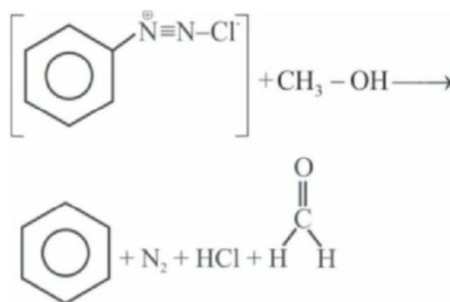
HINTS & SOLUTIONS



6. Sol: At room temperature, it decomposes.

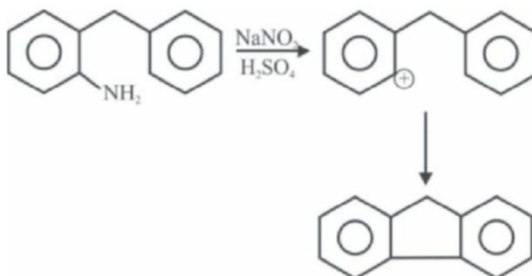
7. Sol: Reduction reaction

10. Sol:

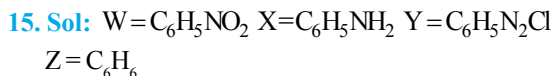


12. Sol: Primary nitro compound forms nitrolic acid which dissolves in alkali to give red solution.

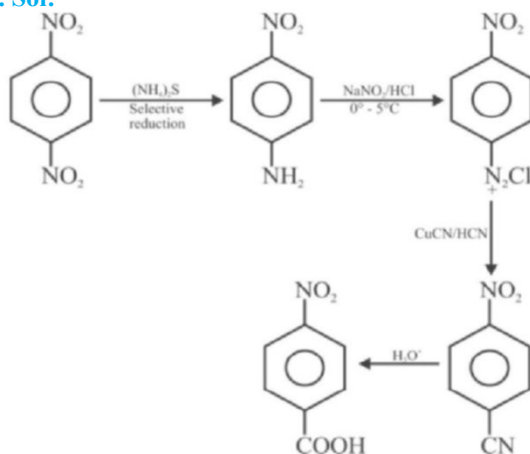
13.Sol:



14. Sol: Given reaction is called Gomberg reaction



16. Sol:



17. Sol: EWG increases coupling reaction.

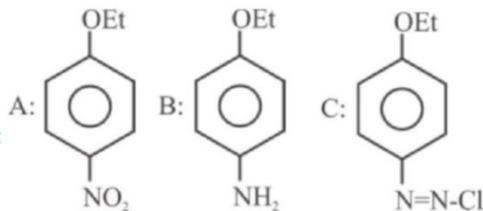
18. Sol: Excess of HCl is used to convert free aniline to aniline hydrochloride. Otherwise free aniline would undergo coupling reaction with benzene diazonium chloride.

19. Sol: 2° amine.

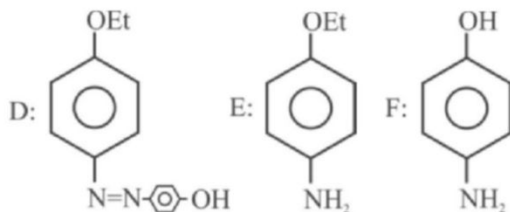
20. Sol: It is unstable and explodes in the solid state.

22. Sol: Due to strong EWG i.e., $-\text{NO}_2$ attached to diazonium ring.

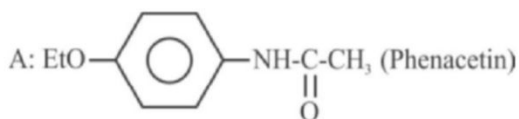
23. Sol: B : PhN_2^+ C : $\text{C}_6\text{H}_5 - \text{D}$



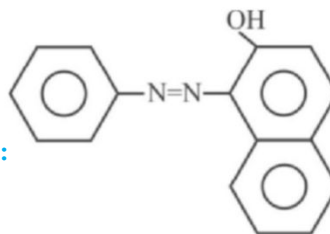
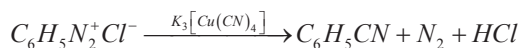
24. Sol:



25. Sol:



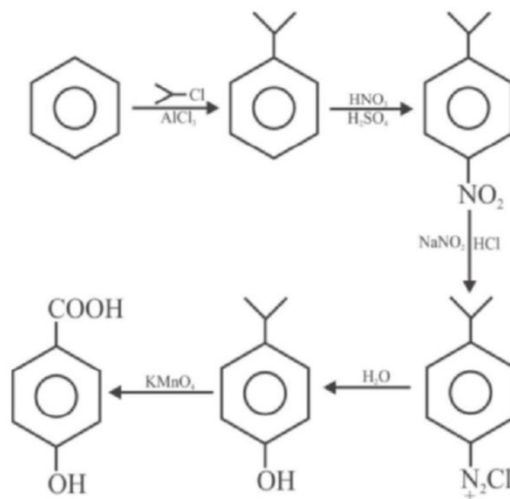
26. Sol:



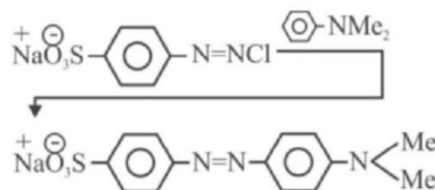
27. Sol:

28. Sol: In cases where a $-\text{COOH}$ or $-\text{SO}_3\text{H}$ group is present at p-position to $(-\text{OH})$ or to $(-\text{NH}_2)$, it is replaced by the azo group during coupling (it is an example of ipso substitution)

29. Sol:



30. Sol:

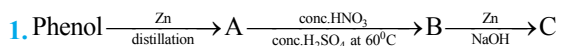


MOCK TEST PAPER

NEET - 4

2018

2019



In the above reaction, compounds (A), (B) and (C) are respectively

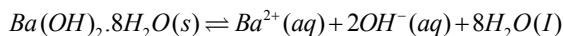
- (a) benzene, nitrobenzene and hydrazobenzene
 - (b) benzene, nitrobenzene and aniline
 - (c) benzene, dinitrobenzene and m-nitroaniline
 - (d) toluene, m-nitrobenzene and m-toluidine
2. The number of enantiomeric pairs that is produced by the monochlorination of 2-Methylbutane is
- (a) 1
 - (b) 2
 - (c) 3
 - (d) 4
3. How many geometric isomers or diastereomers are possible for 2-methyl-2,4,6-octatriene?
- (a) 2
 - (b) 3
 - (c) 4
 - (d) 5
4. Which is the most suitable reagent among the following to distinguish compound (C) from the rest of the compounds
- (A) $\text{CH}_3\text{C} \equiv \text{CH}$
 - (B) $\text{CH}_3\text{CH}_2 - \text{CH}_2\text{CH}_3$
 - (C) $\text{CH}_3\text{CH}_2\text{C} \equiv \text{CH}$
 - (D) $\text{CH}_3\text{CH} = \text{CH}_2$
 - (a) Br_2 in CCl_4
 - (b) Br_2 in CH_3COOH
 - (c) Alkaline KMnO_4
 - (d) Tollen's reagent
5. Benzene on catalytic oxidation at 500°C with V_2O_5 as catalyst gives:
- (a) Maleic anhydride
 - (b) Acetylene
 - (c) Maleic acid
 - (d) None of these
6. If n and l are the principal and azimuthal quantum numbers, then the expression for calculating the total number of electrons an energy level can accommodate is

$$\begin{aligned} \text{(a)} \sum_{l=1}^{l=n} 2(2l+1) & \quad \text{(b)} \sum_{l=1}^{l=n-1} 2(2l+1) \\ \text{(c)} \sum_{l=0}^{l=n+1} 2(2l+1) & \quad \text{(d)} \sum_{l=0}^{l=n-1} 2(2l+1) \end{aligned}$$

7. The number of disulphide linkages present in insulin

are

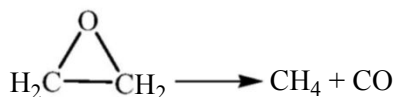
- (a) 4
 - (b) 3
 - (c) 2
 - (d) 1
8. Proteins when heated with conc. HNO_3 give yellow colour. This is
- (a) Oxidising test
 - (b) Hoppe's test
 - (c) Xanthoprotic test
 - (d) Acid - base test
9. Which acid gives wine red colour with neutral FeCl_3 ?
- (a) Propanoic acid
 - (b) Acetic acid
 - (c) Formic acid
 - (d) None of these
10. In which set of molecules all the species are paramagnetic?
- (a) $\text{B}_2, \text{O}_2, \text{N}_2$
 - (b) $\text{B}_2, \text{O}_2, \text{NO}$
 - (c) $\text{B}_2, \text{F}_2, \text{O}_2$
 - (d) $\text{B}_2, \text{O}_2, \text{Li}_2$
11. Which expression correctly represents solubility product for:



- (a) $K_{sp} = [\text{Ba}^{2+}][\text{OH}^-]^2$
- (b) $K_{sp} = [\text{Ba}^{2+}][2\text{OH}^-]^2$
- (c) $K_{sp} = [\text{Ba}^{2+}][\text{OH}^-]^2[\text{H}_2\text{O}]^8$
- (d) $K_{sp} = [\text{Ba}^{2+}][\text{OH}^-]^2[8\text{H}_2\text{O}]^8$

12. Half-life of a zero order reaction is 250 sec. $t_{75\%}$, $t_{100\%}$ of the reaction respectively in sec are
- (a) 500, 375
 - (b) 375, 500
 - (c) 300, 575
 - (d) 575, 300
13. The rate constant for the first order decomposition of the ethylene oxide into CH_4 and CO is described

$$\text{by } \log k (\text{s}^{-1}) = 14.34 - \frac{12.5 \times 10^4 \text{ K}}{T}$$



Then the activation energy of the reaction is

- (a) $2.39 \times 10^5 \text{ kJ mol}^{-1}$ (b) $2.39 \times 10^3 \text{ kJ mol}^{-1}$
 (c) $4.78 \times 10^5 \text{ kJ mol}^{-1}$ (d) $4.78 \times 10^2 \text{ kJ mol}^{-1}$
14. The value of 'spin only' magnetic moment for one of the following configuration is 2.84 B.M. The correct one is:
 (a) d^4 (in strong field ligand)
 (b) d^2 (in weak field ligand)
 (c) d^3 (in weak as well as in strong field ligand)
 (d) d^5 (in strong field ligand)
15. Which one of the following is expected to exhibit optical isomerism?
 (a) trans - $[\text{Co(en)}_2\text{Cl}_2]$
 (b) trans - $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
 (c) Cis - $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
 (d) Cis - $[\text{Co(en)}_2\text{Cl}_2]$
16. The complex compound in which metal is not present in zero oxidation state?
 (a) $[\text{Ni}(\text{CO})_4]$ (b) $K[\text{PtCl}_3(\text{C}_2\text{H}_4)]$
 (c) $\text{Mn}_2(\text{CO})_{10}$ (d) $[\text{Cr}(\text{C}_6\text{H}_6)_2]$
17. Cr^{2+} reducing and Mn^{3+} oxidising when both have d^4 configuration because
 (a) Cr^{2+} attain d^3 i.e., half filled t_{2g} configuration by losing electron
 (b) Mn^{3+} to Mn^{2+} ion attain half filled d^5 configuration by gaining electron.
 (c) By losing electron Cr becomes reducing while by gaining Mn become oxidising and both attain stability.
 (d) All the above
18. Arrange Ce^{3+} , La^{3+} , Pm^{3+} and Yb^{3+} in the increasing order of their ionic radii :
 (a) $\text{Yb}^{3+} < \text{Pm}^{3+} < \text{Ce}^{3+} < \text{La}^{3+}$
 (b) $\text{Ce}^{3+} < \text{Yb}^{3+} < \text{Pm}^{3+} < \text{La}^{3+}$
 (c) $\text{Yb}^{3+} < \text{Pm}^{3+} < \text{La}^{3+} < \text{Ce}^{3+}$
 (d) $\text{Pm}^{3+} < \text{La}^{3+} < \text{Ce}^{3+} < \text{Yb}^{3+}$
19. The oxidation potential of 0.05 M H_2SO_4 is
 (a) -2×0.0591 (b) -0.01×0.0591
 (c) -2.321×0.0591 (d) 0.0591
20. In the treatment of domestic sewage water, the weight of oxygen that can be required to oxidise 10mg of carbon is
 (a) 2.67mg (b) 26.7mg (c) 5gr (d) 10gr
21. A gas is heated in such a way so that its pressure and volume both become double. Again by lowering temperature, one fourth of initial number of moles of air has been taken in, to maintain the double volume and pressure. By what fraction, the temperature must have been raised finally?
 (a) 1/5 (b) 4/5 (c) 16/5 (d) 8/5
22. Critical temperature of carbon dioxide gas is 30.98°C . Its expected boiling point is
 (a) 92.94°C (b) 30.98°C
 (c) 10.33°C (d) 20.65°C
23. The enolic form of acetone contains
 (a) 9 σ bonds, 1 π bond and 2 lone pairs
 (b) 8 σ bonds, 2 π bonds and 2 lone pairs
 (c) 10 σ bonds, 1 π bond and 1 lone pair
 (d) 9 σ bonds, 2 π bonds and 1 lone pair
24. In a Lassaignes's test for sulphur in the organic compound with sodium nitroprusside solution the purple colour formed is due to
 (a) $\text{Na}_4[\text{Fe}(\text{CN})_5\text{NOS}]$ (b) $\text{Na}_3[\text{Fe}(\text{CN})_5\text{S}]$
 (c) $\text{Na}_2[\text{Fe}(\text{CN})_5\text{NOS}]$ (d) $\text{Na}_3[\text{Fe}(\text{CN})_6]$
25. Which of the following possesses highest melting point ?
 (a) Chlorobenzene (b) o-Dichlorobenzene
 (c) m-Dichlorobenzene (d) p-Dichlorobenzene
26. In the presence of peroxide, hydrogen chloride and hydrogen iodide do not give anti-Markovnikov's addition to alkenes because
 (a) both are highly ionic
 (b) one is oxidising and the other is reducing
 (c) one of the steps is endothermic in both cases
 (d) all steps are exothermic in both cases.
27. Which of the following reagents and conditions can convert benzene into chlorobenzene ?
 (a) Cl_2 , sunlight, heat (b) HCl , heat
 (c) HCl , sunlight, heat (d) Cl_2 , AlCl_3 , heat
28. Find out the value of K_c for the following equilibria from the value of K_p
- $$\text{CaCO}_{3(s)} \rightleftharpoons \text{CaO}_{(s)} + \text{CO}_{2(g)}$$
- $K_p = 167\text{atm}$ at 1073K
- (a) 167molL^{-1} (b) $1.89\text{mol}^{-1}\text{L}$
 (c) $167\text{mol}^{-1}\text{L}$ (d) 1.89molL^{-1}
29. The formula to find pH of the aqueous solution of an amphoteric salt NaHS is
 (a) $[pK_{a1} + pK_{a2}]$ (b) $1/2[pK_{a1} + pK_{a2}]$
 (c) $[pK_{a1} - pK_{a2}]$ (d) $1/2[pK_{a1} - pK_{a2}]$

30. What will happen, if anode is made of nickel instead of graphite in the extraction of aluminium from $AlCl_3$?
- Nickel will be affected by high temperature
 - Nickel will combine with Cl_2
 - Nickel is insulator
 - All of these
31. Ratio of O_2 and N_2 in the air is 1:4. Find out the ratio of solubilities in terms of mole fraction of O_2 and N_2 dissolved in water at atmospheric pressure and room temperature
- $$\left[\begin{array}{l} K_H [O_2] = 3.30 \times 10^7 \text{ torr} \\ K_H [N_2] = 6.60 \times 10^7 \text{ torr} \end{array} \right]$$
- 1 : 2
 - 2 : 1
 - 1 : 1
 - None of these
32. Equimolal solutions of potassiumhexacyanoferrate (II), (represented as X) and potassium hexacyanoferrate (III), (represented as Y) are considered, which are at equal degree of dissociation. Which of the following statement is correct?
- The boiling point of X is greater than Y.
 - X and Y have the same boiling point.
 - The boiling point of X is less than Y.
 - X and Y have the same freezing point.
33. Which one of the following properties of white phosphorus are shown by red phosphorus?
- It dissolves in CS_2
 - It burns when heated in air
 - It reacts with NaOH to give PH_3
 - It phosphorescences in air
34. In the compounds of the type POX_3 , P atoms show multiple bonding of the type is
- $p\pi - p\pi$
 - $d\pi - d\pi$
 - $p\pi - d\pi$
 - None of these
35. Sulphuric acid reacts with PCL_5 to give
- Thionyl chloride
 - Sulphur monochloride
 - Sulphuryl chloride (SO_2Cl_2)
 - Sulphur tetrachloride
36. When Cl_2 water is added to an aqueous solution of potassium halide in presence of chloroform a violet colour is obtained on adding more of Cl_2 water; the violet colour disappears and a colourless solution is obtained. This test confirms the presence of the following in aqueous solution:
- Iodide
 - Bromide
 - Chloride
 - Iodide and bromide
37. XeF_6 on reaction with KF yields
- $K^+ [XeF_7]^-$
 - $[XeF_4]^{+2} [KF_3]^{-2}$
 - $[XeF_5]^+ [KF_2]^-$
 - None of these
38. The order that is not in accordance with the property stated against it is
- $F_2 > Cl_2 > Br_2 > I_2$: Oxidising power
 - $HI > HBr > HCl > HF$: Acidic property in water
 - $F_2 > Cl_2 > Br_2 > I_2$: Electronegativity
 - $F_2 > Cl_2 > Br_2 > I_2$: Bond dissociation energy
39. If N_1, N_2, N_3, \dots are the number of molecules with molecular masses M_1, M_2, M_3, \dots respectively, then average molecular mass is expressed as
- $\frac{\sum N_i M_i}{\sum N_i}$
 - $\frac{\sum N_i M_i^2}{\sum N_i M_i}$
 - Both of these
 - None of these
40. What is the equivalent weight of NH_3 in the given reaction?
- $$3CuO + 2NH_3 \rightarrow 3Cu + N_2 + 3H_2O$$
- 17
 - $\frac{17}{4}$
 - $\frac{17}{2}$
 - $\frac{17}{3}$
41. A deliquescent white crystalline hydroxide X reacts with a nitrate Y to form another hydroxide which decomposes to give an insoluble brown layer of its oxide. X is a powerful cautery and breaks down the proteins of skin flesh to a pasty mass. X and Y are
- NaOH, $AgNO_3$
 - NaOH, $Zn(NO_3)_2$
 - NaOH, $Al(NO_3)_3$
 - $Ca(OH)_2$, $HgNO_3$
42. Mixture of $MgCl_2$ and MgO is called
- Portland cement
 - Sorel's cement
 - Double salt
 - None
43. On rising temperature and decreasing pressure in CsCl solid
- $\frac{r_+}{r_-}$ (radius ratio) is increased
 - Density of unit cell is increased

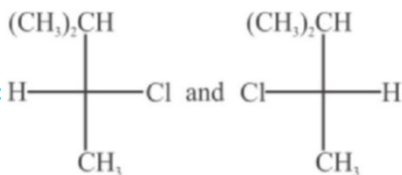
- (c) C.N. of metal ion increases from 6 to 8
 (d) Number of formula unit per unit cell (Z) changes from one to four
44. The gold number of three substances A, B and C are 0.05, 0.8 and 0.3. The substance with maximum protective power is
 (a) A (b) B (c) C (d) All of these
45. Assuming ideal behaviour, what is the entropy of mixing (ΔS_{mix}) 1 mol of $\text{N}_{2(g)}$ with 1 mol of $\text{O}_{2(g)}$ at the same temperature and pressure?
 (a) 0.693 J/(K mol) (b) 1.39 J/(K mol)
 (c) 5.76 J/(K mol) (d) 11.5 J/(K mol)

ANSWER KEY

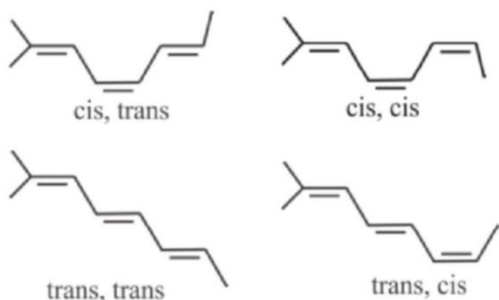
- | | | | | |
|-------|-------|-------|-------|-------|
| 1. a | 2. a | 3. c | 4. d | 5. a |
| 6. d | 7. b | 8. c | 9. b | 10. b |
| 11. a | 12. b | 13. b | 14. b | 15. d |
| 16. b | 17. d | 18. a | 19. d | 20. b |
| 21. c | 22. d | 23. a | 24. a | 25. d |
| 26. c | 27. d | 28. d | 29. c | 30. b |
| 31. a | 32. a | 33. b | 34. c | 35. c |
| 36. a | 37. a | 38. d | 39. c | 40. d |
| 41. a | 42. b | 43. d | 44. a | 45. d |

HINTS & SOLUTIONS

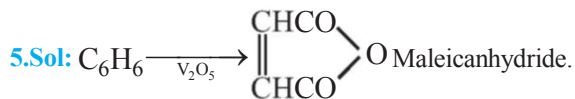
- 1.Sol: $A = \text{C}_6\text{H}_6$, $B = \text{C}_6\text{H}_5\text{NO}_2$
 C=Hydrazobenzene



- 3.Sol: Four geometric isomers are possible. $N = 2^n = 2^2 = 4$,
 n = Number of double bonds with different substituent at both end.
 The structures are



- 4.Sol: Terminal alkynes ($\equiv \text{C}-\text{H}$) give white precipitate with Tollen's reagent (ammoniacal AgNO_3)



- 9.Sol: It is a test for acetate radical.

- 11.Sol: Hydration does not influence the K_{SP} value.

- 12.Sol: For zero order reaction,

$$t_{3/4} = \frac{1}{k} \left([\text{A}]_0 - \frac{1}{4} [\text{A}]_0 \right) = \frac{3}{4} \frac{[\text{A}]_0}{k}$$

$$t_{1/2} = \frac{1}{k} \left([\text{A}]_0 - \frac{1}{2} [\text{A}]_0 \right) = \frac{1}{2} \frac{[\text{A}]_0}{k}$$

$$\frac{t_{3/4}}{t_{1/2}} = \frac{3}{2} \Rightarrow t_{3/4} = 1.5 \times t_{1/2}$$

$$t_{75\%} = \frac{3}{2} t_{50\%}$$

$$t_{100\%} = 2t_{50\%}$$

- 13.Sol: $\log k = \log A - \frac{E_a}{2.303 RT} \dots (i)$

$$\log k = 14.34 - \frac{12.5 \times 10^4 \text{ K}}{T} \dots (ii)$$

From Eqs. (i) and (ii)

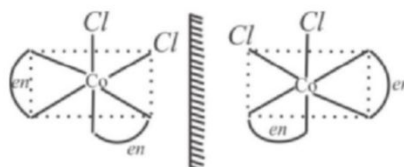
$$\frac{E_a}{2.303R} = 12.5 \times 10^4 \text{ K}$$

$$\begin{aligned} E_a &= (12.5 \times 10^4 \text{ K}) \times 2.303 \times 8.314 \text{ JK}^{-1} \text{ mol}^{-1} \\ &= 239 \times 10^4 \text{ J mol}^{-1} \\ &= 2.39 \times 10^6 \text{ J mol}^{-1} \\ &= 2.39 \times 10^3 \text{ kJ mol}^{-1} \end{aligned}$$

14. Sol: Magnetic moment $= \sqrt{n(n+2)} = 2.84$

$\therefore n = 2$ (i.e., number of unpaired electron)

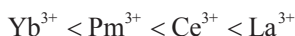
- 15.Sol: Cis isomer can be resolved in two forms if molecule is M_{A_2BC} , where A is bidentate ligand.



16.Sol: Pt is in +2 oxidation state

17.Sol: Cr^{2+} is reducing as its configuration changes from d^4 to d^3 , the latter having a half-filled t_{2g} level. On the other hand, the change from Mn^{3+} to Mn^{2+} results in the half-filled (d^5) configuration which has extra stability.

18.Sol: Due to lanthanide contraction, order will be



19.Sol: $2\text{H}^+ + 2\text{e}^- \longrightarrow \text{H}_2$

$$E_{\text{Red}} = E_{\text{Red}}^0 - \frac{0.059}{n} \log \frac{1}{[\text{H}^+]^2};$$

$$E_{\text{Red}} = 0 - \frac{0.059}{2} \log \frac{1}{(0.1)^2}; E_{\text{Red}} = -0.059 \text{ V},$$

$$E_{\text{oxi}} = 0.059 \text{ V}.$$

21.Sol: $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow \frac{P_1 V_1}{T_1} = \frac{2P_1 \times 2V_1}{T_2} \Rightarrow T_2 = 4T_1$

When air has been taken in and P, V remain

constant; $n_1 \cdot 4T_1 = n_2 \cdot T_2$

Initial no. of moles = n

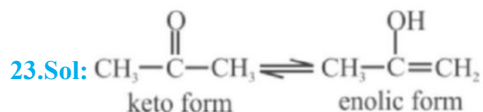
$$n_1 = n \text{ and } n_2 = n + \frac{1}{4}n = \frac{5}{4}n$$

$$\text{Total} = n_1 + \frac{n_1}{4} = \frac{5}{4}n_1$$

$$\therefore n \cdot 4T_1 = \frac{5}{4}n \cdot T_2 \Rightarrow T_2 = \frac{16}{5}T_1$$

22.Sol: Expected b.p. of $\text{CO}_2 = \frac{2}{3}T_c$ (Gulberg Rule)

$$= \frac{2}{3} \times 30.98 = 20.65^\circ\text{C}$$



No. of σ bonds in enolic form :

$$3 + 1 + 1 + 1 + 1 + 2 = 9$$

No. of π bonds in enolic form : 1; No. of lone pairs of electrons in enolic form = 2

25.Sol: Due to symmetrical structure, p-dichlorobenzene fits closely in the crystal lattice.

26.Sol: The reaction of HCl with carbon radical in case of HCl, and addition of iodine radical to double bond in case of HI are endothermic steps.

27.Sol: $\text{C}_6\text{H}_6 + \text{Cl}_2 \xrightarrow{\text{AlCl}_3} \text{C}_6\text{H}_5\text{Cl}.$

29.Sol: pH of aqueous solution of an amphoteric salt is equal to the average of the pKa of the salt and its conjugate acid.

31.Sol: $p_{\text{O}_2} = \frac{1}{5} \times 1 = 0.2 \text{ bar}$

$$p_{\text{N}_2} = \frac{4}{5} \times 1 = 0.8 \text{ bar}$$

$$P = K_{\text{H}} X \text{ (Henry's law)}$$

$$\frac{X_{\text{O}_2}}{X_{\text{N}_2}} = \frac{p_{\text{O}_2}}{K_{\text{H}}(\text{O}_2)} \times \frac{K_{\text{H}}(\text{N}_2)}{p_{\text{N}_2}} = \frac{0.2 \times 6.60 \times 10^7}{0.8 \times 3.30 \times 10^7} = \frac{1}{2}$$

37.Sol: $\text{KF} + \text{XeF}_6 \longrightarrow \text{K}^+ [\text{XeF}_7]^-$

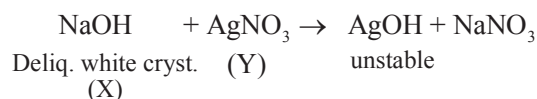
38.Sol: Bond dissociation energy is in the order $\text{Cl}_2 > \text{F}_2 > \text{Br}_2 > \text{I}_2$ because of repulsion between lone pairs in F atoms due to small size.

39.Sol: Number average molecular mass

$$\overline{Mn} = \frac{\sum N_i M_i}{\sum N_i}$$

$$\text{Mass average molecular mass } \overline{Mw} = \frac{\sum N_i M_i^2}{\sum N_i M_i}$$

41.Sol:



42.Sol: The mixture of MgCl_2 and MgO is known as sorer's cement.

43.Sol: On rising temperature and decreasing pressure in CsCl (s) number of formula units increases

44.Sol: Protective power $\propto \frac{1}{\text{Gold number}}$

45.Sol: $\Delta_{\text{mixing}} S_{\text{system}} = -R \left[\sum n_i \ln \chi_i \right]$

$$= -R \left[1 \cdot \ln \frac{1}{2} + \ln \frac{1}{2} \right] = 2R \ln 2 = 11.5 \text{ J/(mol K)}$$



PRACTICE CORNER

EQUILIBRIUM

(PREVIOUS YEAR NEET QUESTIONS)

1. MY and NY_3 , two nearly insoluble salts, have the same K_{sp} values of 6.2×10^{-13} at room temperature. Which statement would be true in regard to MY and NY_3 ? [2016]
 - (a) The addition of the salt of KY to solution of MY and NY_3 will have no effect on their solubilities.
 - (b) The molar solubilities of MY and NY_3 in water are identical.
 - (c) The molar solubility of MY in water is less than that of NY_3 .
 - (d) The salts MY and NY_3 are more soluble in 0.5 M KY than in pure water.
2. In the equilibrium constant for $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is K , the equilibrium constant for $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO(g)$ will be [2015]

(a) K (b) K^2 (c) $K^{1/2}$ (d) $\frac{1}{2}K$
3. If the value of equilibrium constant for a particular reaction is 1.6×10^{12} , then at equilibrium the system will contain [2015]
 - (a) mostly products
 - (b) similar amounts of reactants and products
 - (c) all reactants
 - (d) mostly reactants
4. Which of the following statements is correct for a reversible process in a state of equilibrium? [2015]
 - (a) $\Delta G^\circ = -2.30RT \log K$
 - (b) $\Delta G^\circ = 2.30RT \log K$
 - (c) $\Delta G = -2.30RT \log K$
 - (d) $\Delta G = 2.30RT \log K$
5. For a given exothermic reaction, K_p and K'_p are the equilibrium constants at temperature T_1 and T_2 , respectively. Assuming that heat of reaction is constant in temperature range between T_1 and T_2 , it is readily observed that [2014]
 - (a) $K_p > K'_p$ (b) $K_p < K'_p$
 - (c) $K_p = K'_p$ (d) $K_p = \frac{1}{K'_p}$
6. For the reversible reaction,

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{heat}$$
 The equilibrium shifts in backward direction [2014]
 - (a) By increasing the concentration of $NH_3(g)$
 - (b) By decreasing the pressure
 - (c) By decreasing concentration of $N_2(g)$ and $H_2(g)$
 - (d) All the above
7. Given the reaction between 2 gases represented by A_2 and B_2 to given the compound $AB(g)$.

$$A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$$
 At equilibrium, the concentration of $A_2 = 3.0 \times 10^{-3} M$
 of $B_2 = 4.2 \times 10^{-3} M$
 of $AB = 2.8 \times 10^{-3} M$
 If the reaction takes place in a sealed vessel at $527^\circ C$, then the value of K_c will be [2012]

(a) 2.0 (b) 1.9 (c) 0.62 (d) 4.5

ANSWER KEY

- | | | | |
|------|------|------|------|
| 1. c | 2. c | 3. a | 4. a |
| 5. a | 6. d | 7. c | |

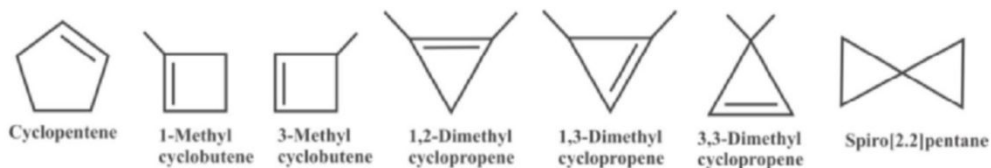
Synopticglance

HYDROCARBONS-3

(Alkynes) Introduction

- Unsaturated hydrocarbons containing at least one $\text{—C}\equiv\text{C—}$ are alkynes.
- General formula of alkynes is $\text{C}_n\text{H}_{2n-2}$
- $\text{—C}\equiv\text{C—}$ contain 1σ & 2π bonds.
No: of **Linear atoms in alkynes** around triple bond-Two sp carbons + 2 atoms attached to them = 4
- Carbons involved in triple bond undergoes 'sp' hybridisation. Bond angle 180°
- Order of bond lengths $\text{C—C} > \text{C=C} > \text{C}\equiv\text{C}$
 $1.54 \text{ \AA}^0 \quad 1.33 \text{ \AA}^0 \quad 1.20 \text{ \AA}^0$
- C-H bond length in acetylene (1.06 \AA^0) is less than C-H bond length in ethylene (1.09 \AA^0) because of the sp hybridisation.
- Order of bond energies in KJ mol^{-1} $\text{C}\equiv\text{C} > \text{C=C} > \text{C—C}$
 $828 \quad 598 \quad 348$
- The hydrogen on the triple bonded carbon is acidic due to more 's' character.

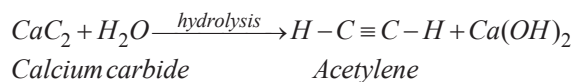
Ring chain isomers -Cycloalkene and Spirane



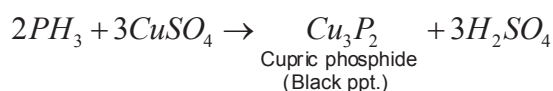
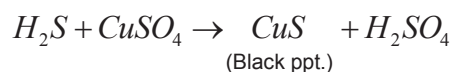
Methods of preparations

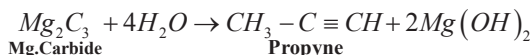
(1) Action of water on metal carbides of II group

- **Industrial preparation:** Calcium carbide on hydrolysis gives **Acetylene or Ethyne**.



Purification. Acetylene obtained by the above method generally contains the impurities of hydrogen sulphide and phosphine. This is due to the contamination of calcium sulphide and calcium phosphide in calcium carbide. These impurities are removed by bubbling the gas through acidified copper sulphate solution.





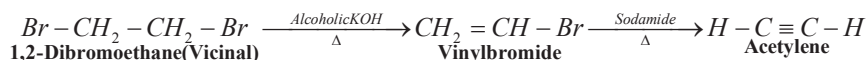
(2) From Halohydrocarbons

○ By dehydrohalogenation of dihalides

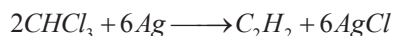
Dehydrohalogenation of Geminal or Vicinal dihalides gives alkynes.

Reagents: i) **Alcoholic KOH** ii) **Sodamide (Na / Liq. NH₃)**

- Dehydrohalogenation of Vicinal dihalides also yield alkynes. The reaction proceeds in two steps and different dehydrohalogenating agents are used for every step. Stronger base like **sodamide** is needed for the **second step**.

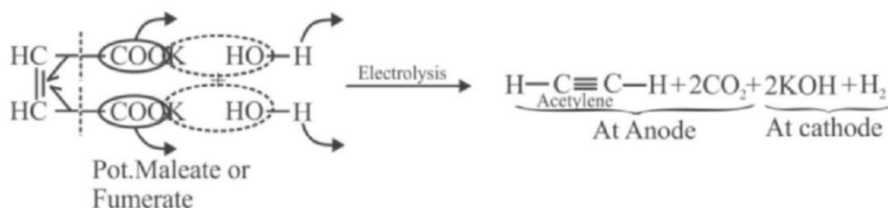


- **By the action of zinc on tetrahalogen derivatives of alkanes (Dehalogenation)** On treatment with zinc, tetrahalides get dehalogenated to give alkynes.
- **From haloform** : Acetylene can be prepared by heating Chloroform or Iodoform with silver.



(3) Kolbe's electrolysis

Electrolysis of aqueous solution of potassium salt of Maleic or Fumaric acid gives Acetylene.

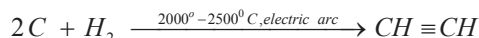


(4) Synthesis from carbon and hydrogen

Acetylene can be prepared by passing a stream of hydrogen through electric arc struck between carbon electrodes at 3270K

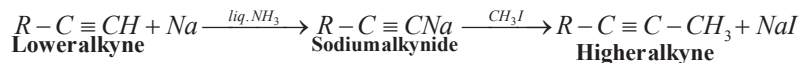


Bertholite synthesis : Ethyne can be synthesized by this method

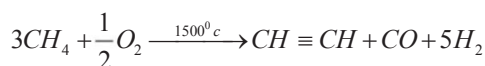
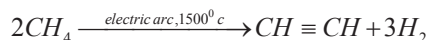


(5) From acetylene

Higher alkynes are prepared from acetylene by treating its sodium salt with alkylhalide. The sodium salt is prepared by the action of sodamide on acetylene in the presence of diethylether.



(6) From methane



Physical properties

- First three alkynes are gases, the next eight are liquids and the higher alkynes are solids.
- These are weakly polar in nature.

- These are lighter than water, immiscible in water but soluble in organic solvents.
- As molecular weight increases, melting point, boiling point and solubility in organic solvents increases.
Melting points and boiling points of alkynes are higher than those of corresponding alkanes and alkenes because alkynes have linear structure due to which molecules are more closely packed.
- Acetylene is a colourless gas with garlic odour due to the presence of impurities like phosphine etc

Chemical Properties

- Due to presence of at least one triple bond in alkynes they are quite reactive chemically.
- They readily take part in addition reactions and can also be easily oxidised.
- Alkynes undergo addition reactions in an analogous fashion to those of alkenes.
- The high electron density of the **pi** bonds makes them nucleophilic.
- Two factors influence the relative reactivity of alkynes compared to alkenes:
 - (a) Increased nucleophilicity of the terminal **pi** system ($\text{C} \equiv \text{C}$ vs $\text{C}=\text{C}$), and
 - (b) Stability of any intermediates (for example carbocations)

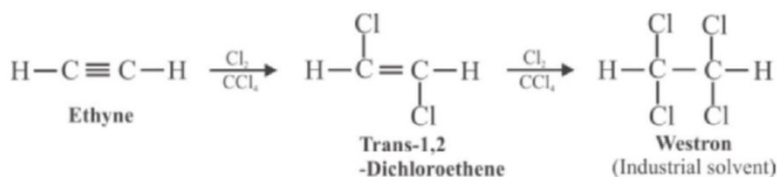
(I) Electrophilic Addition Reactions

Like alkenes, alkynes undergo electrophilic addition reactions due to their unsaturated nature.

Compared to alkenes, the electrophilic additions to alkynes are much slower.

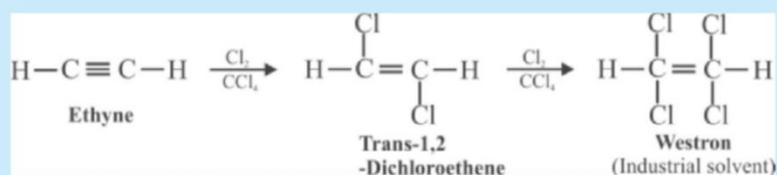
The addition process occurs in two steps.

(I) *Addition of halogens*: Halogens add to alkynes in two steps forming a dihalide and then tetrahalide.



IMPORTANT POINTS

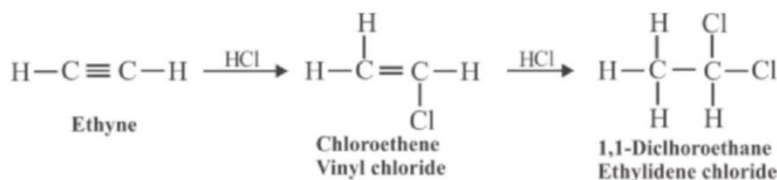
Unsaturation test: The discharge of the reddish brown colour of bromine on addition to alkynes indicates the presence of unsaturation (alkenes or alkynes).



(II) Addition of halogen acids

The addition of halogen acids (HCl , HBr , and HI) results Geminal dihalo compounds in two steps.

If symmetrical alkyne is used 2nd step of the reaction takes place according to Markovnikov's rule.



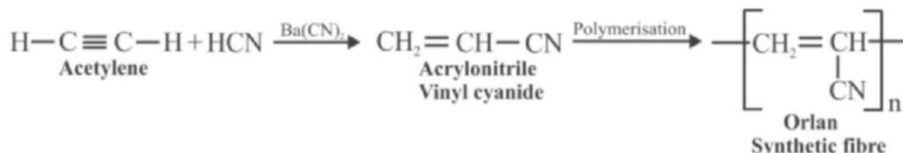
(III) Addition of hypohalous acid (HOX)

Alkynes react with two molecules of hypohalous acids (HOCl or HOBr) or halogen Cl_2 or Br_2 in the presence of H_2O and produce carbonyls (Aldehydes and Ketones)

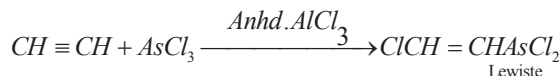
The reaction proceeds through Markovnikov's addition.

**(IV) Addition of Hydrogen Cyanide**

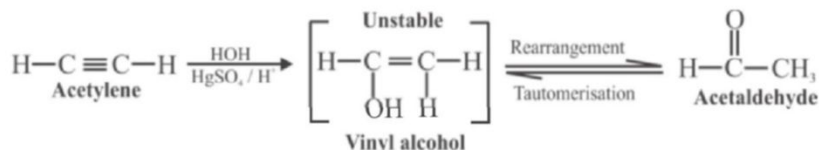
Alkynes react with hydrogen cyanide (HCN) in the presence of Barium cyanide catalyst. Acetylene gives vinyl cyanide or acrylonitrile, which can be used to prepare synthetic fibre **orlon**.



(V) Addition of Arsenic trichloride (AsCl_3): Acetylene reacts with AsCl_3 to yield Lewisite (Poisonous gas), used in chemical war.

**(2) Addition of water**

Alkynes react with water in the presence of mercuric sulphate (HgSO_4) and sulphuric acid at 348K. The products are carbonyl compounds (aldehydes and ketones).

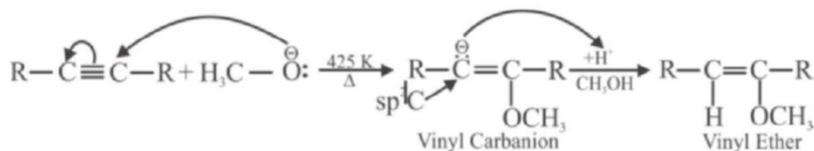
**Among Alkynes**

- Only acetylene gives Aldehyde.
- Other alkynes give Ketones as the final product.

(3) Nucleophilic addition reactions

Addition of nucleophile to alkyne gives a vinyl carbanion whose negative charge is on sp^2 hybrid carbon atom. Due to more s-character it is more stable and more readily formed when compared to the product formed by addition of nucleophile to alkene (alkyl carbanion whose negative charge on sp^3 C.)

Hence alkynes are more reactive than alkenes toward nucleophilic addition.



Comparison of the reactivity of following towards nucleophilic addition with MeONa / MeOH
More EWG, more is reactivity towards NPA since vinyl carbocation is stabilised due to EWG.

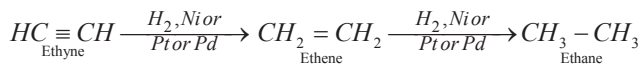
Terminal alkynes are more reactive than the internal alkynes.

Order of reactivity of various alkyne derivatives.

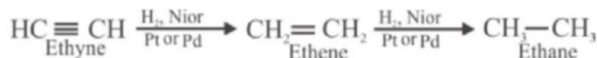


(4) Addition of hydrogen (hydrogenation)

Alkynes react readily with hydrogen in the presence of finely divided Ni, Pt or Pd as catalysts.

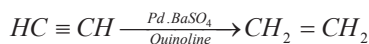


○ Hydrogenation can be controlled at the alkene stage by using Lindlar's catalyst and Sodium in Liq. Ammonia.



○ Lindlar's catalyst

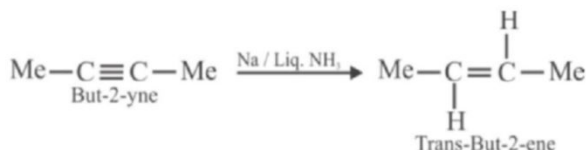
- It is a mixture of Palladium and Barium sulphate poisoned by Quinoline.
- The "poisoned" catalyst prevents over-reduction otherwise which would give the alkane thru alkene.
- The new C-H bonds are formed simultaneously from H atoms absorbed on to the metal surface.
- Stereochemical aspects:** The reaction is **stereospecific** giving only the **syn** addition product.



(Lindlar's catalyst) Ethene

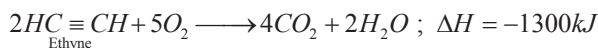
○ Sodium dissolved in liquid ammonia

- It gives solvated electrons which reduce the alkyne.
- The reaction proceeds via single electron transfer from the Na with H coming from the NH_3 .
- These reaction conditions do not reduce alkenes, hence the product is the alkene.
- Stereochemical aspects:** This reaction is **stereospecific** giving only **anti** addition product.



(5) Oxidation: Alkynes can be oxidised under different conditions to give a variety of products.

(I) Combustion

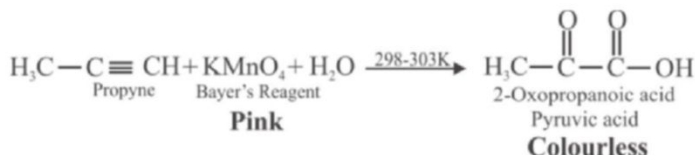


The heat produced during the combustion of acetylene can be used for welding purposes in the form of **Oxyacetylene** flame.

(II) Oxidation with Potassium permanganate

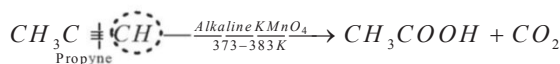
○ Alkynes react with cold alkaline $KMnO_4$ solution and form diketones.

This reaction is used for detection of unsaturation. The pink colour of the reagent is discharged if unsaturation is present.

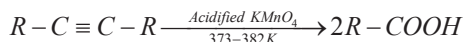


○ Alkynes react with Hot acidic $KMnO_4$ solution and form Carboxylic acids and Carbondioxide depending upon the position of triple bond. The cleavage occurs at the site of triple bond.

Terminal triple bond gives Carbondioxide and Carboxylic acid



Non terminal triple bond give two carboxylic acids.

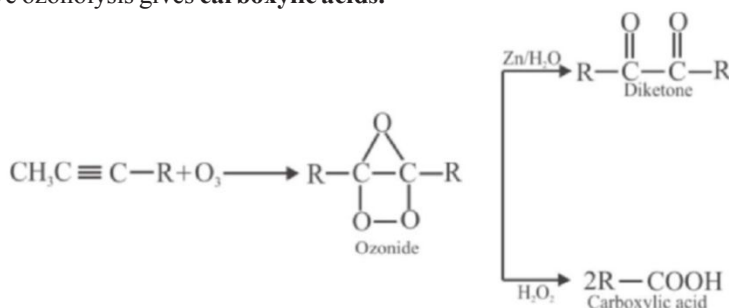


The above reactions in which triple bond is completely broken are called **degradation or cleavage** reactions.

These can be used to locate the position of triple bond.

(III) **Oxidation with ozone (Ozonolysis)**

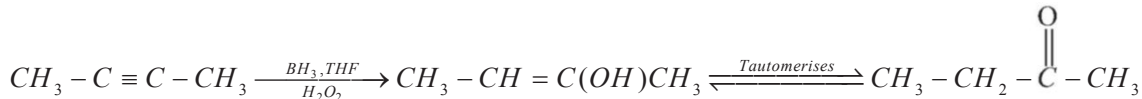
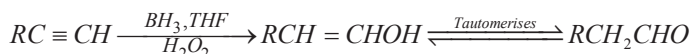
- The alkynes react with ozone to form ozonides.
- Reductive ozonolysis (water /Zn) gives **diketones**.
- Oxidative ozonolysis gives **carboxylic acids**.



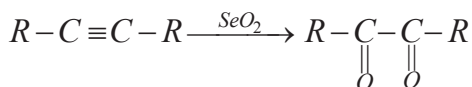
(IV) **Hydro-Boration-Oxidation:** Alkynes on Hydroboration oxidation give Alkenols which tautomerises to Carbonyls.

Reagent : BH_3 in THF + H_2O_2

Terminal alkynes give Aldehydes while non-terminal alkynes give ketones.



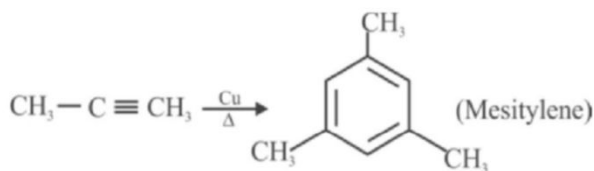
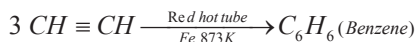
(V) **Oxidation by SeO_2 :** Alkynes are oxidised to Dicarboxyls (Diketones and Dials)



(6) Polymerisation Reactions

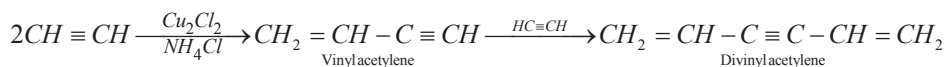
Alkynes have lesser tendency to polymerise than alkenes. Therefore, these give low molecular mass polymers.

- Alkynes when passed through a red hot iron tube polymerise to give aromatic hydrocarbons. Acetylene polymerizes to benzene.

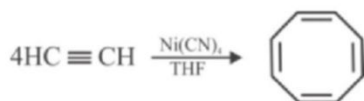


- When acetylene is passed through cuprous chloride solution containing NH_4Cl **linear polymerisation** occurs resulting to monovinyl and divinyl acetylene. Acetylene undergoes linear polymerisation to form polyethyne or poly acetylene containing repeating units of $-CH = CH - CH = CH -$ Thin films of

polyacetylene are used as electrodes in batteries because these films are good conductors.



- In the presence of $Ni(CN)_2$ and under high pressure acetylene dissolves in THF polymerises to give cyclo octatetraene.



(7) Acidity of Alkynes

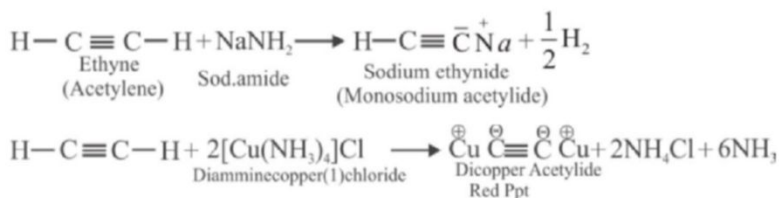
Acetylene and other terminal alkynes (1-alkynes) are weakly acidic in character.

Reasons

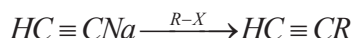
- The electron pair of $H - C \equiv$ bond gets displaced more towards the 'sp' carbon atom and helps in the release of H^+ ion.

(I) Reaction with Bases

They react with strong bases like $NaNH_2$ (or sodium in liquid ammonia) to form sodium acetylide derivatives known as acetylides or alkynides.



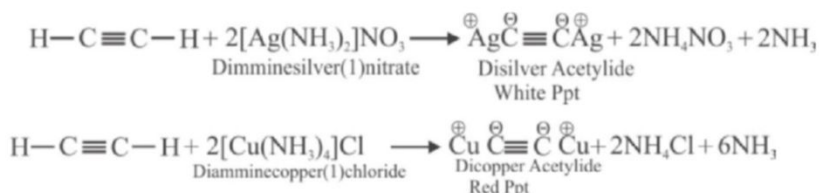
Acetylides react with alkyl halides to give higher alkynes



(II) Reaction with Ammonical Metal salt solutions

The Acetylenic hydrogen of alkynes can be replaced by copper (I) or silver (I) ions.

They react with ammoniacal solutions of cuprous chloride and silver nitrate to form the corresponding copper and silver alkynides.

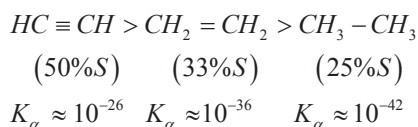


IMPORTANT POINTS

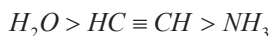
- ❑ This reaction can be used to distinguish between 2-alkynes and 1-alkynes.
- ❑ Reason : Only terminal alkynes react with ammoniacal solution of silver nitrate or cuprous chloride.

(III) Comparison of relative acidic strengths of alkanes, alkenes and alkynes

The acidic character decreases as:



The relative acidity of acetylene is more than that of ammonia but less than that of water.

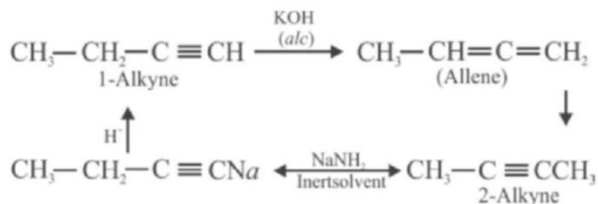


Order of acidic nature of various alkynes



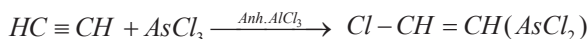
(8) Isomerisation

The following reactions can be used to convert 1-Alkyne to 2-alkyne and vice versa.



(9) Uses of Acetylene

- In ripening of raw fruits.
- For illumination in carbide lamps
- In oxyacetylene flame from cutting and welding of metals.
- In the manufacture of **Lewisite**, which is used as a war gas.

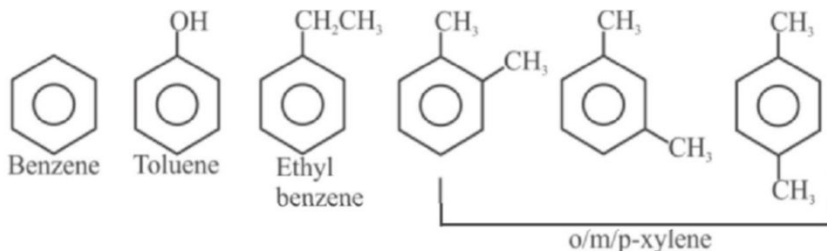


- In the preparation of a synthetic plastic (**P.V.C.**), preparation of polyacrylonitrile (acrolein or orlon), manufacture of synthetic polyisoprene rubber.

Benzene

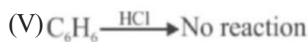
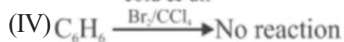
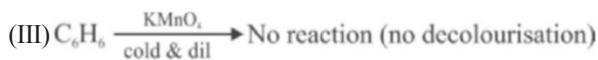
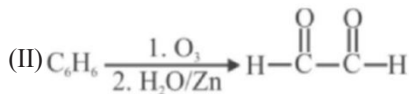
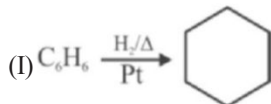
- These are also called arenes.
- General formula is C_nH_{2n-6} . Where y is the number of benzene ring in molecule.

E.g:

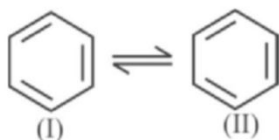


Structure of Benzene

(I) Following reactions are important in the determination of the structure of benzene.



On the basis of (I) and (II) reactions Kekule in 1865 suggested that benzene is equilibrium mixture of cyclohexatrienes [(a) and (b)] as follows

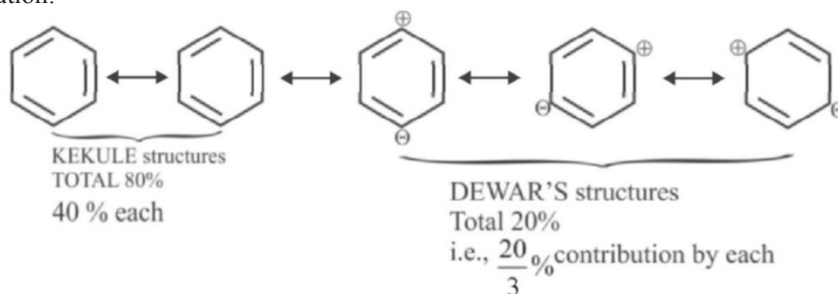


But reaction (III), (IV) and (V) can not be explained by Kekule's structure.

(2) The Resonance Hybrid Structure

According to the resonance theory, benzene is a resonance hybrid of the following canonical forms.

Contribution:



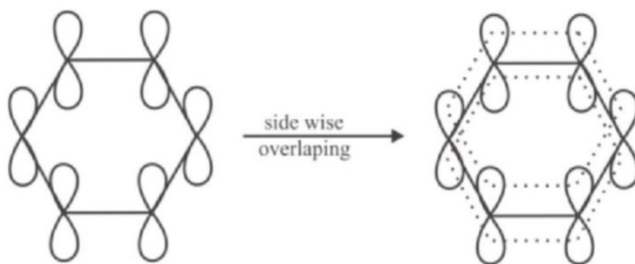
It should be noted that the concept of resonance is imaginary and the canonical forms mentioned above actually do not exist. It is the hybrid structure which is a reality.

○ RESONANCE THEORY CAN EXPLAIN

- Stability of π – electrons.
- Equal bond energies of all C–C bond.
- Equal bond lengths of all C–C bond.
- Lower value of heat of combustion.
- Lower value of heat of hydrogenation.

(3) The Molecular Structure of Benzene

According to this theory, all of the six carbon atoms in benzene ring are in sp^2 hybridised state. By overlapping of hybrid orbitals these six carbon atoms form a planar hexagonal ring. Now each of 'p' orbital on the six carbon atoms can overlap on either side with adjacent 'p' orbitals. These result in a molecular orbital which is actually made of two continuous rings, one ring above and another below the plane of hexagon.



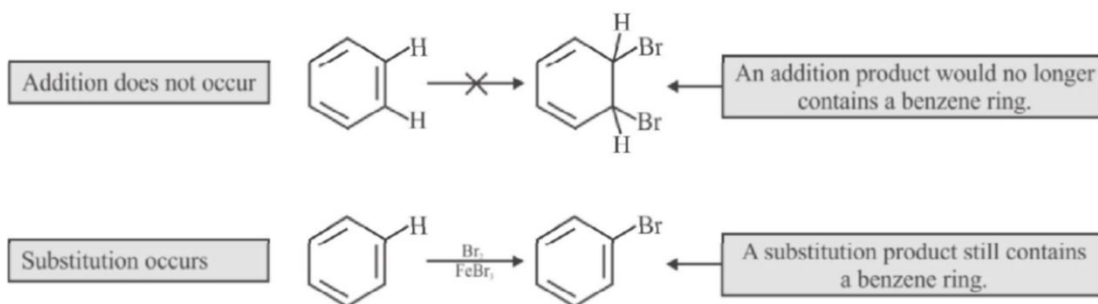
Aromaticity of Benzene

Why do we care if a compound is aromatic or not?

Because we encounter aromatics every single day of our lives. Without aromatic compounds, we would not only be lacking many material necessities, our bodies would also not be able to function. Aromatic compounds are essential in industry; about 35 million tonnes of aromatic compounds are produced in the world every year to produce important chemicals and polymers, such as polyester and nylon.

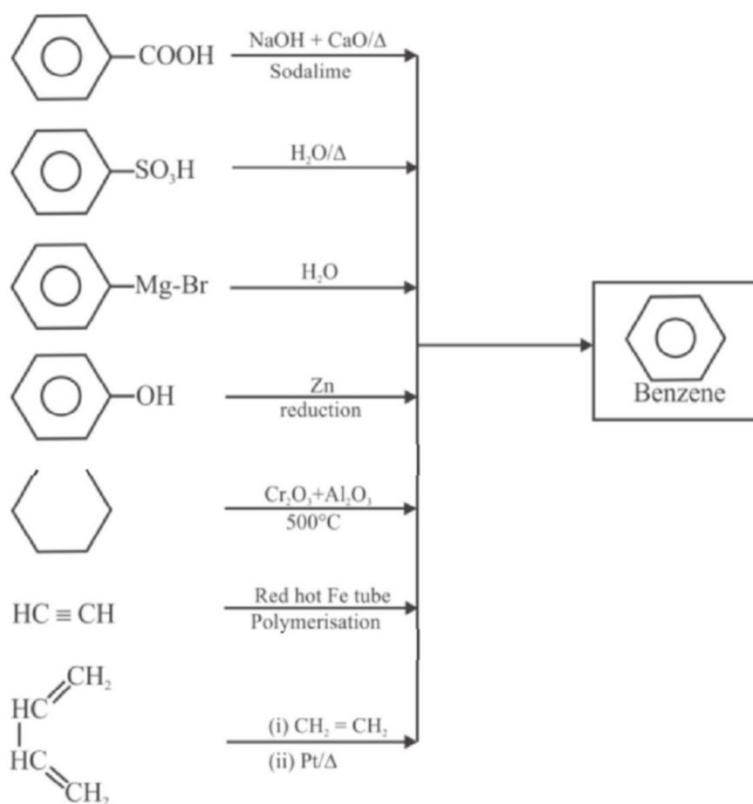
Aromatic compounds are also vital to the biochemistry of all living things. Three of the twenty amino acids used to form proteins ("the building blocks of life") are aromatic compounds and all five of the nucleotides that make up DNA and RNA sequences are all aromatic compounds. Needless to say, aromatic compounds are vital to us in many aspects.

The word *aromaticity* has evolved as understanding of the special properties of benzene and other aromatic molecules has deepened. Originally, aromaticity was associated with a specific chemical reactivity. The aromatic hydrocarbons undergo substitution reactions in preference to addition. Later, the idea of special stability became more important.



Aromaticity is now generally associated with this property of special stability of certain completely conjugated cyclic molecules. A major contribution to the stability of aromatic system comes from the delocalization of π electrons in these molecules, which also imparts other properties that are characteristic of aromaticity, especially a diamagnetic ring current.

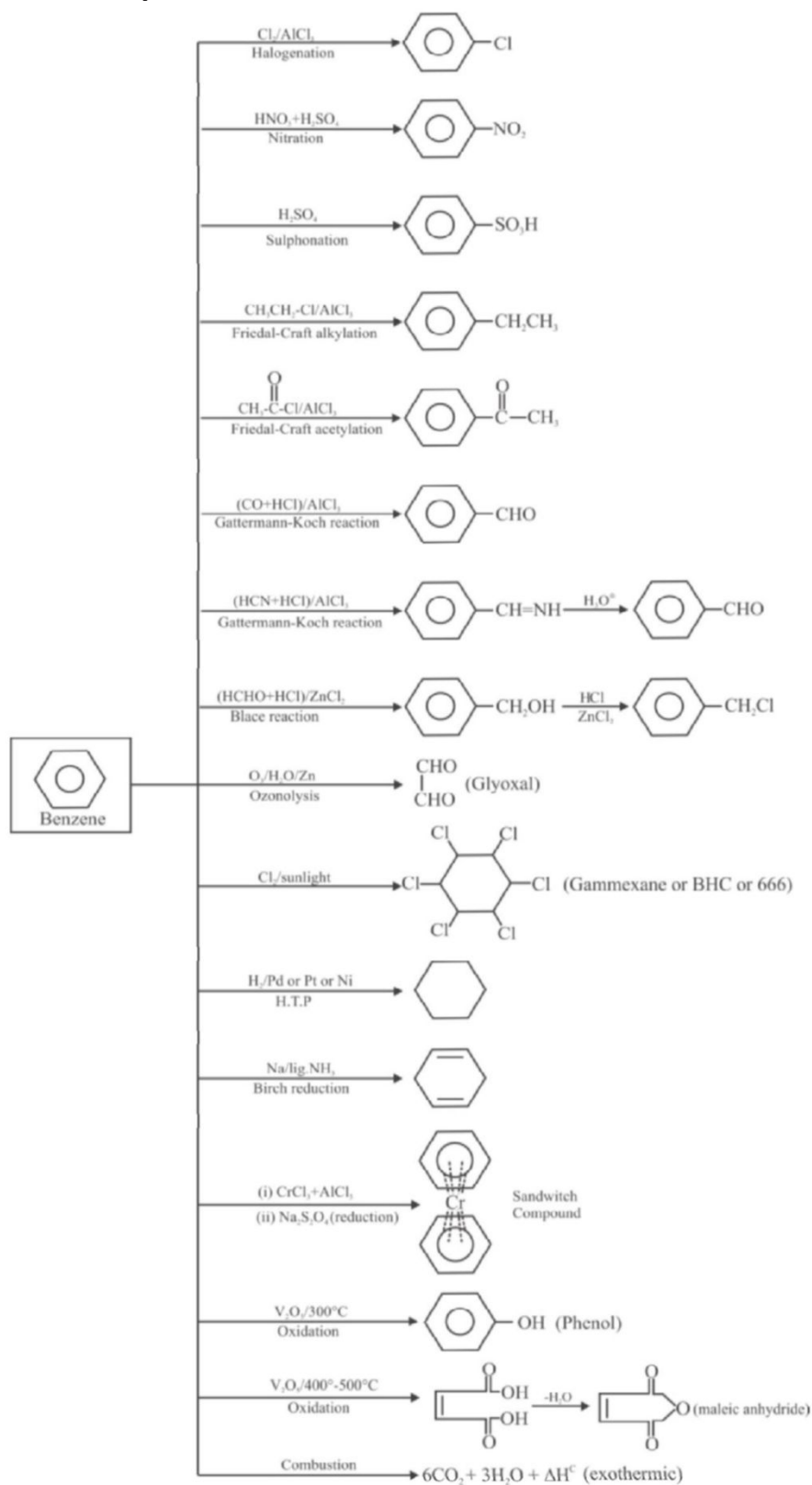
Preparation Methods of Benzene



Physical Properties

- Benzene is a colourless volatile liquid. It has characteristic smell.
- Its boiling point is 80°C and freezing point is 5.5°C .
- It is highly inflammable and burns with sooty flame.
- It is lighter than water. Its specific gravity at 20°C is 0.8788.
- It is immiscible with water but miscible with organic solvents such as alcohol and ether.
- It is a non - polar compound and its dipole moment is zero.
- It is extremely poisonous substance. Inhalation of vapours or absorption through skin has a toxic effect.

Chemical Properties



MOCK TEST PAPER

JEE MAIN - 3

2018

2019

1. O_2 and N_2 if converted to O_2^+ and N_2^+ respectively.

The incorrect statement is

- (a) Electron in O_2 goes from $\pi_{2p_y}^*$
 (b) Electron in N_2 goes from σ_{2p_z}
 (c) Bond length $O-O >$ bond length $(O-O)^+$
 (d) Bond length $N-N >$ bond length $(N-N)^+$

2. Boron when heated with carbon forms

- (a) BC_2 (b) B_4C_3 (c) B_2C_3 (d) B_4C

3. Which of the following will give maximum number of isomers ?

- (a) $[Co(NH_3)_4Cl_2]$ (b) $[Ni(en)(NH_3)_4]^{2+}$
 (c) $[Ni(C_2O_4)(en)_2]$ (d) $[Cr(SCN)_2(NH_3)_4]^{2+}$

4. The overall complex dissociation equilibrium constant for the $Cu(NH_3)_4^{2+}$ ion, given that β_4 for this complex is 2.1×10^{13} is

- (a) 2.1×10^{13} (b) 4.7×10^{-14}
 (c) 2.1×10^{-13} (d) 4.7×10^{14}

5. Plumbo-solvency refers to :

- (a) Oxidation of lead to lead oxide
 (b) Oxidation of lead to red lead
 (c) Dissolution of lead in water containing air
 (d) Making lead wires by forcing heated metal through a dye

6. Metamers of ethylpropionate are

- (a) C_4H_9COOH and $HCOOC_4H_9$
 (b) C_4H_9COOH and $CH_3OOC_3H_7$
 (c) CH_3COOCH_3 and $CH_3OOC_3H_7$

- (d) $CH_3COOC_3H_7$ and $C_3H_7COOCH_3$

7. In column chromatography the MOVING PHASE is constituted by

- (a) A substance which have to be separated
 (b) Eluent
 (c) Adsorbent
 (d) Mixture of eluent and substances to be separated

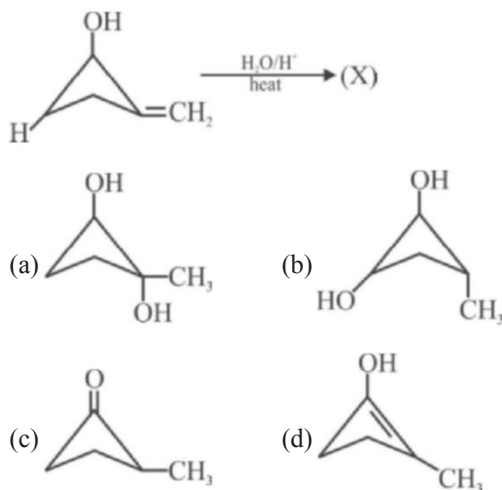
8. Which of the following should be done in order to prepare a 0.6 M NaCl starting with 100ml of 0.3 M NaCl. (M.wt of NaCl = 58.5)?

- (a) Add 5.85 g NaCl
 (b) Add 20ml of water
 (c) Add 0.03 moles NaCl
 (d) Evaporate 10ml of water

9. 5.47 g of Mg metal reacted completely with 14.31 g of a non metal. The compound of this non metal with hydrogen contains 3.1% H. The equivalent weight of Mg is

- (a) 24 (b) 11.95 (c) 13.5 (d) 48

10. Consider the following reactions



11. Phenol reacts with which one of the following reagents gives a conjugate diketone will be formed ?

(a) $Na_2Cr_2O_7$ (b) *conc.* HNO_3
(c) Zn, Δ (d) $Na_2Cr_2O_7 + H_2SO_4$

12. 1-Chlorobutane on reaction with alcoholic potash gives

(a) But-1-ene (b) Butan-1-ol
(c) Butan-2-one (d) Butan-2-ol

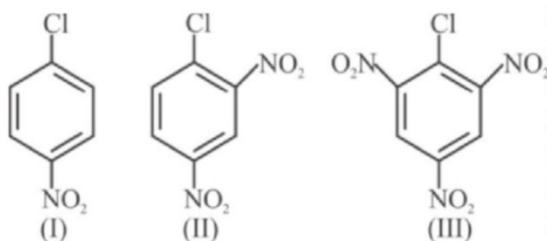
13. Which of the following reagents and conditions can convert benzene into chlorobenzene ?

(a) Cl_2 , sunlight, heat (b) HCl , heat
(c) HCl , sunlight, heat (d) $Cl_2, AlCl_3$, heat

14. A compound of molecular weight 180 is acetylated to give a compound of molecular weight 390. The number of amino groups in the initial compound is :

(a) 2 (b) 4 (c) 5 (d) 6

15. Aryl halides are extremely less reactive towards nucleophilic substitution. Predict the order of reactivity of the following compounds towards nucleophilic substitution



(a) $III > II > I$ (b) $II > III > I$
(c) $I > II > III$ (d) $I > III > II$

16. Reaction of methylene chloride with excess of benzene in presence of anhydrous $AlCl_3$ gives

(a) $C_6H_5CH_2Cl$ (b) $C_6H_5CH_2C_6H_5$
(c) $C_6H_5CHCl_2$ (d) None of these

17. Which of the following statements is false?

(a) Photochemical smog causes irritation in eyes
(b) London smog is a mixture of smoke and fog
(c) Photochemical smog results in the formation of PAN
(d) London smog is oxidising in nature

18. The ionisation constant of benzoic acid is 6.46×10^{-5} and K_{sp} for silver benzoate is

2.5×10^{-13} . How many times is silver benzoate more soluble in a buffer of pH 3.19 as compared to its solubility in pure water?

(a) 2 (b) 3.32 (c) 4 (d) 4.32

19. 0.96 g of HI was heated till the equilibrium

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ is reached. The reaction mixture was suddenly cooled and the amount of iodine produced required 15.7 mL (N/10) hypo solution. The K_p for the above equilibrium reaction is

(a) 7.5×10^{-3} (b) 7.85×10^{-4}
(c) 5.93×10^{-3} (d) 17.5×10^{-3}

20. Two gas containers with volumes 0.1 L and 1L respectively are connected by a tube of negligible volume and contains air at a pressure of 1000 mm of Hg at $0^\circ C$. If the temperature of smaller container is raised to $100^\circ C$, the volume of air measured at $0^\circ C$ and 760 mm of Hg that will pass from it to larger container will be

(a) 30 mL (b) 42.3 mL (c) 32.9 mL (d) 12 mL

21. For the non-zero value of force of attraction between gas molecules, gas equation will be

(a) $PV = nRT - \frac{n^2 a}{V}$ (b) $PV = nRT + nbP$

(c) $PV = nRT$ (d) $P = \frac{nRT}{V - b}$

22. PCl_5 dissociates as follows in a closed reaction vessel $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$. If total pressure at equilibrium of the reaction mixture is P and degree of dissociation of PCl_5 is x, the partial pressure of PCl_5 will be

(a) $\left[\frac{x}{x-1} \right] P$ (b) $\left[\frac{x}{1-x} \right] P$

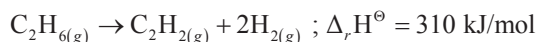
(c) $\left[\frac{1-x}{1+x} \right] P$ (d) $\left[\frac{2x}{1-x} \right] P$

23. Solid $AgNO_3$ is added to a solution which is 0.1 M in CrO_4^{2-} . K_{sp} values of $AgCl$ and Ag_2CrO_4 are 1.7×10^{-10} and 1.9×10^{-12} respectively. The

concentration of Cl^- when Ag_2CrO_4 starts precipitating will be:

- (a) $3.9 \times 10^{-5} M$ (b) $2.9 \times 10^{-5} M$
(c) $3.9 \times 10^{-3} M$ (d) $1.9 \times 10^{-2} M$

24. Industrial acetylene gas (ethyne, C_2H_2) is made by the high temperature decomposition of ethane gas, C_2H_6 , at $300^\circ C$, according to the following equation :



If the value of the thermodynamic equilibrium constant, K_{eq} , for reaction at $300^\circ C$ is 1.68×10^{-16} which one of the following statements about this reaction is correct?

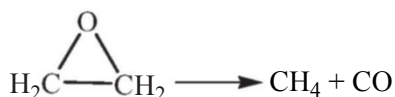
- (a) $\Delta_r G^\ominus > \Delta_r H^\ominus$ and $\Delta_r S^\ominus > 0$
(b) $\Delta_r G^\ominus < \Delta_r H^\ominus$ and $\Delta_r S^\ominus < 0$
(c) $\Delta_r G^\ominus < \Delta_r H^\ominus$ and $\Delta_r S^\ominus > 0$
(d) $\Delta_r G^\ominus > \Delta_r H^\ominus$ and $\Delta_r S^\ominus < 0$

25. If the rate constant for the disintegration of a radioactive nucleus is λ . Therefore, the probability P of survival of a radioactive nucleus for one mean life is

- (a) e (b) e^2 (c) e^{-1} (d) e^{-2}

26. The rate constant for the first order decomposition of the ethylene oxide into CH_4 and CO is described

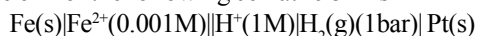
$$\text{by } \log k (s^{-1}) = 14.34 - \frac{12.5 \times 10^4 \text{ K}}{T}$$



Then the activation energy of the reaction is

- (a) $2.39 \times 10^5 \text{ kJ mol}^{-1}$ (b) $2.39 \times 10^3 \text{ kJ mol}^{-1}$
(c) $4.78 \times 10^5 \text{ kJ mol}^{-1}$ (d) $4.78 \times 10^2 \text{ kJ mol}^{-1}$

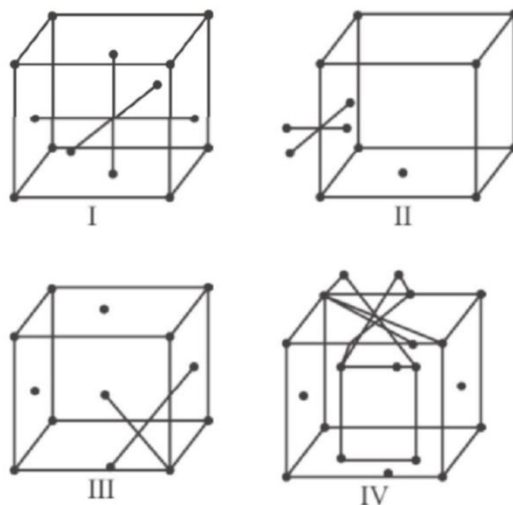
27. The emf of the following cell at 298 K is



$$\text{Given } E^\ominus_{(\text{Fe}^{2+}/\text{Fe})} = -0.44 \text{ V}$$

- (a) 0.44 V (b) 0.53 V
(c) 0.35 V (d) Data insufficient

28.



- (a) I, II and IV represent octahedral holes
(b) I and II represent octahedral holes
(c) I and II represent tetrahedral holes
(d) II, III and IV represent tetrahedral holes

29. The flame colours of metal ions are due to

- (a) Frenkel defect
(b) Metal deficiency defect
(c) Schottky defect
(d) Metal excess defect

30. 1 molal aqueous solution of an electrolyte A_2B_3 is 60% ionised. The boiling point of the solution at 1 atm is ($K_{b(H_2O)} = 0.52 \text{ K kg mol}^{-1}$)

- (a) 274.76 K (b) 377 K
(c) 376.4 K (d) 374.76 K

ANSWER KEY

- | | | | | |
|-------|-------|-------|-------|-------|
| 1. d | 2. d | 3. d | 4. b | 5. c |
| 6. d | 7. d | 8. c | 9. b | 10. c |
| 11. d | 12. a | 13. d | 14. c | 15. a |
| 16. b | 17. d | 18. b | 19. d | 20. c |
| 21. a | 22. c | 23. a | 24. c | 25. c |
| 26. b | 27. b | 28. b | 29. d | 30. d |

HINTS & SOLUTIONS

1. Sol: Conceptual

2.Sol: $4B + C \xrightarrow{\Delta} B_4C$. The molecular formula of boron carbide is $B_{12}C_3$.

3. Sol: The complex ion $[Cr(SCN)_2(NH_3)_4]^{2+}$ can exhibit geometrical and linkage isomerism.

4. Sol: The overall dissociation constant is the reciprocal of overall stability constant i.e., $1/\beta_4 = 4.7 \times 10^{-14}$. $\beta_4 = k_1 \times k_2 \times k_3 \times k_4$

5.Sol: Lead dissolves in water containing dissolved air, due to the formation of lead hydroxide. This solvent action of water on lead is called plumbo solvency.

6.Sol: Ethylpropionate is $C_2H_5COOC_2H_5$.

7. Sol: Conceptual

8.Sol: $V_1M_1 = V_2M_2$

9.Sol:

Weight of Mg = 5.47 g

Weight of non metal = 14.31 g

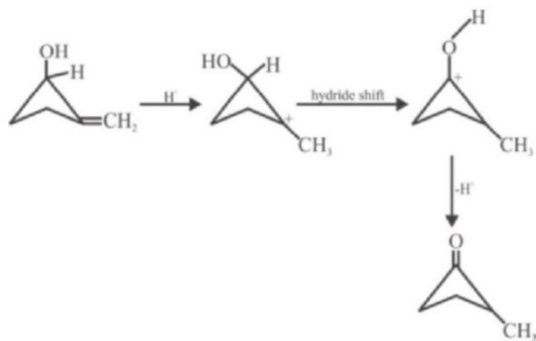
Weight of non metal in hydrogen compound = 100 - 3.1 = 96.9

14.31 g of non metal contains $\frac{3.1}{96.9} \times 14.31 = 0.4578$

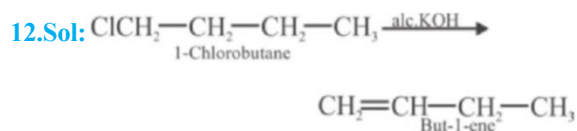
g of H_2

Equivalent of Mg = $\frac{5.47}{0.4578} \times 1 = 11.95$

10.Sol:



11.Sol: Conjugate diketone is known as benzoquinone.



13.Sol: $C_6H_6 + Cl_2 \xrightarrow{AlCl_3} C_6H_5Cl$.

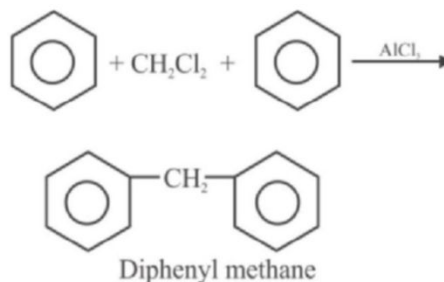
14.Sol: Difference in mass of compound = $390 - 180 = 210$

Weight of CH_3CO - group = 43

\therefore Number of $-NH_2$ group = $\frac{210}{43} = 4.88 = 5$

15.Sol: More number of EWG more is reactivity towards S_N^{Ar}

16.Sol: This is an extension of Friedel-Crafts' reaction



17. Sol: Conceptual

18.Sol: For silver benzoate (C_6H_5COOAg)

$$K_{sp} = [C_6H_5COO^-][Ag^+] = 2.5 \times 10^{-13} \quad \dots(i)$$

If S' is the solubility of silver benzoate in pure water, then

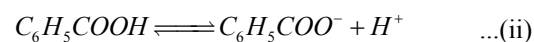
$$S' = \sqrt{K_{sp}} = \sqrt{2.5 \times 10^{-13}} = 5 \times 10^{-7} \text{ mol L}^{-1}$$

$$pH = 3.19 \Rightarrow -\log[H^+] = 3.19$$

$$\log[H^+] = -3.19$$

$$[H^+] = 6.457 \times 10^{-4} M$$

For benzoic acid in aqueous solution,



$$\frac{[C_6H_5COO^-]}{[C_6H_5COOH]} = \frac{K_a}{[H^+]} = \frac{6.46 \times 10^{-5}}{6.457 \times 10^{-4}} = \frac{1}{10}$$

Suppose solubility of silver benzoate in buffer solution is $y \text{ mol L}^{-1}$ then most of the benzoate ions are converted into benzoic acid molecules (which remain almost ionised), we have

$$\begin{aligned} y &= [Ag^+] = [C_6H_5COO^-] + [C_6H_5COOH] \\ &= [C_6H_5COO^-] + 10[C_6H_5COO^-] \\ &= 11[C_6H_5COO^-] \end{aligned}$$

$$\therefore [C_6H_5COO^-] = \frac{y}{11}$$

$$K_{sp} = [C_6H_5COO^-][Ag^+]$$

$$\text{i.e., } 2.5 \times 10^{-13} = \frac{y}{11} \times y \Rightarrow y^2 = 2.75 \times 10^{-12}$$

$$y = 1.66 \times 10^{-6}$$

$$\therefore \frac{y(\text{solubility in buffer})}{x(\text{solubility in water})} = \frac{1.66 \times 10^{-6}}{5 \times 10^{-7}} = 3.32$$

19.Sol: Initial moles of HI = $\frac{0.96}{128} = 7.5 \times 10^{-3}$

$$\text{Moles of } I_2 \text{ produced} = \frac{15.7 \times 0.1 \times 10^{-3}}{2}$$

$$= 7.85 \times 10^{-4}$$

Moles of HI left undissociated at equilibrium

$$= 7.5 \times 10^{-3} - 2 \times 7.85 \times 10^{-4} = 5.93 \times 10^{-3}$$



$$K = \frac{(7.85 \times 10^{-4})^2}{(5.93 \times 10^{-3})^2} = 17.52 \times 10^{-3}$$

20.Sol: Moles present initially in 1 L container

$$n_1 = \frac{PV}{RT} = \frac{1000 \times 1}{760 \times 0.0821 \times 273} = 5.87 \times 10^{-2}$$

Moles present initially in 0.1 L container

$$n_2 = \frac{PV}{RT} = \frac{1000 \times 0.1}{760 \times 0.0821 \times 273} = 5.87 \times 10^{-3}$$

$$\therefore n_1 + n_2 = 5.87 \times 10^{-2} + 5.87 \times 10^{-3} = 6.46 \times 10^{-2}$$

Also, on heating the vessel of 0.1 L to 373 K, let 'n' moles remain in it. As pressure will remain same, so nRT/V is constant in both the containers.

$$\frac{n \times 373}{0.1} = \frac{(6.46 \times 10^{-2} - n) \times 273}{1} \Rightarrow n = 4.40 \times 10^{-3}$$

$$\text{i.e., Moles left in 0.1 litre container after heating} = 4.40 \times 10^{-3}$$

$$\therefore \text{Moles moved from 0.1 L to 1 L vessel}$$

$$= 5.87 \times 10^{-3} - 4.40 \times 10^{-3} = 1.47 \times 10^{-3}$$

$$\therefore \text{Volume of air moved at } 0^\circ\text{C and } 760 \text{ mm}$$

$$V = \frac{nRT}{P} = \frac{1.47 \times 10^{-3} \times 0.0821 \times 273}{1} = 32.9 \text{ mL}$$

21.Sol: For n mole of a real gas

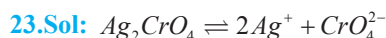
$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$

$$\text{when } \frac{n^2 a}{V^2} \neq 0 \text{ and } nb = 0$$

$$\left(P + \frac{n^2 a}{V^2}\right)V = nRT$$

$$PV + \frac{n^2 a}{V} = nRT \Rightarrow PV = \left(nRT - \frac{n^2 a}{V}\right)$$

22. Sol: Conceptual



$$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$$

$$[Ag^+] = \sqrt{\frac{K_{sp}}{[CrO_4^{2-}]}} = \sqrt{\frac{1.9 \times 10^{-12}}{0.1}} = 4.35 \times 10^{-6} \text{ M}$$

$$K_{sp} \text{ for } AgCl = [Ag^+][Cl^-]$$

$$1.7 \times 10^{-10} = (4.35 \times 10^{-6})[Cl^-]$$

$$[Cl^-] = 3.9 \times 10^{-5} \text{ M}$$

$$\text{24.Sol: } -\Delta_r G^\circ = RT \ln K_{eq} = 173 \text{ kJ/mol}$$

$$\Delta_r G^\circ < \Delta_r H^\circ \text{ and } \Delta_r S^\circ > 0$$

25.Sol: Conceptual

$$\text{26.Sol: } \log k = \log A - \frac{E_a}{2.303 RT} \quad \dots (i)$$

$$\log k = 14.34 - \frac{12.5 \times 10^4 \text{ K}}{T} \quad \dots (ii)$$

From Eqs. (i) and (ii)

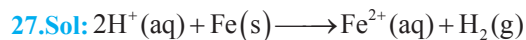
$$\frac{E_a}{2.303 R} = 12.5 \times 10^4 \text{ K}$$

$$E_a = (12.5 \times 10^4 \text{ K}) \times 2.303 \times 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$$

$$= 239 \times 10^4 \text{ J mol}^{-1}$$

$$= 2.39 \times 10^6 \text{ J mol}^{-1}$$

$$= 2.39 \times 10^3 \text{ kJ mol}^{-1}$$



Nernst equation :

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0591}{2} \log \frac{[\text{Fe}^{2+}]}{[\text{H}^+]^2}$$

EMF of the cell, $E_{\text{cell}} =$

$$[0 - (-0.44)] - \frac{0.0591}{2} \log \frac{[10^{-3}]}{[1]^2}$$

$$= 0.44 - \frac{0.591}{2} \times (-3)$$

$$= 0.44 + 0.887$$

$$= 0.5287\text{V} \approx 0.53\text{V}$$

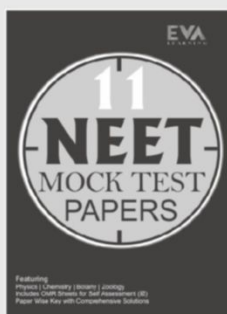
$$\text{EMF} = 0.53\text{V}$$

28.Sol: I and II represent octahedral holes

29.Sol: In metal excess defect when holes created by missing of anions are occupied by electrons, their sites are called F-centres and are responsible for colour in the crystal.

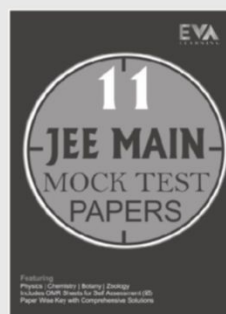
30.Sol: $\Delta T_b = ik_b m$

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1. SOME BASIC CONCEPTS OF CHEMISTRY

(1) Laws of Chemical Combinations

(I) Law of conservation of mass:

During any physical or chemical change the total mass of the products remains equal to the total mass of the reactants.

(II) Law of definite or constant proportions:

A chemical compound always contains same elements combined together in the same proportion by mass irrespective of source

(III) Law of multiple proportions:

If two elements can combine to form two or more compounds, the masses of one of the element which combine with fixed mass of the other bears a simple whole number ratio. This law is also called **law of chemical equivalents**.

(IV) Law of Reciprocal proportions:

When two elements combine separately with

fixed mass of the third element, then the ratio of the masses in which they do so is either same or some whole number multiple of the ratio in which they combine with each other.

(V) Avogadro's law

In 1811, Avogadro proposed that equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

(2) Atomic Mass and Molecular Mass

Atomic mass of an element

$$= \frac{\text{Mass of one atom of the element}}{\frac{1}{12} \text{ th part of mass of one atom of carbon}}$$

$$= \frac{\text{Mass of one atom of the element}}{\text{Mass of one atom of carbon}} \times 12$$

○ Methods of determining atomic mass

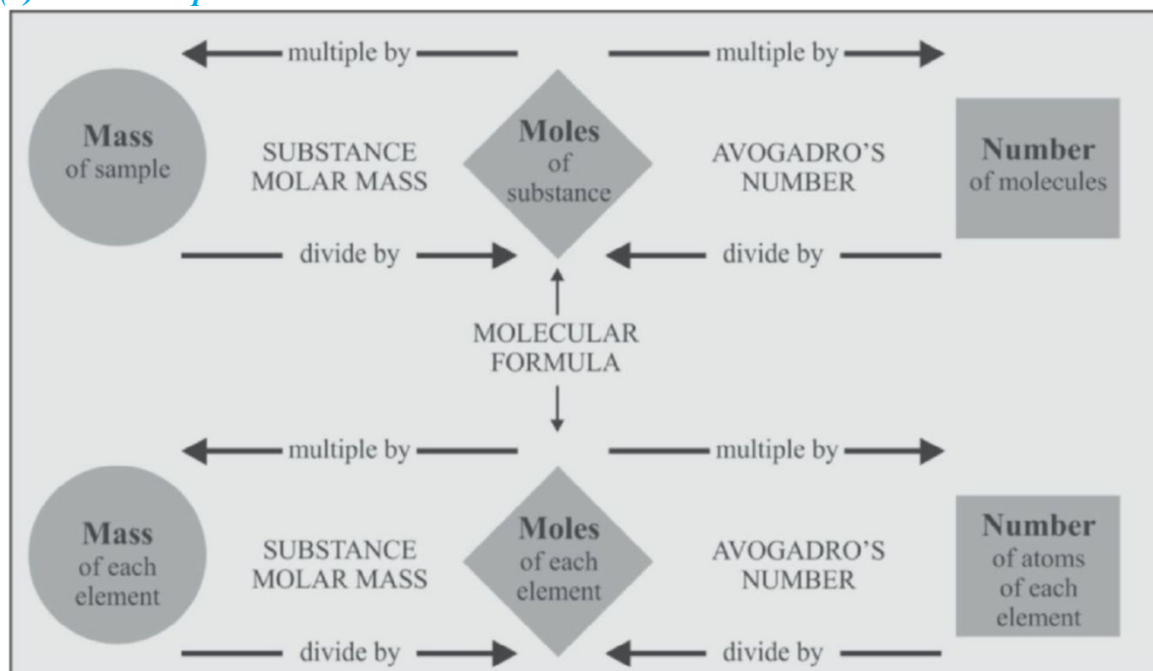
Method	Formula
Dulong and Petit's method	Approx. atomic mass = $\frac{6.4}{\text{Specific heat}}$
	Valency = $\frac{\text{approx. atomic mass}}{\text{Equivalent mass}}$
	Exact atomic mass = Equivalent mass \times Valency
Isomorphism method	Exact atomic mass = Equivalent mass \times Valency
Specific heat/ Molar heat capacity method	Atomic mass of gaseous element = $\frac{\text{Molecular mass}}{\text{Atomicity}}$ (Mol. mass = $2 \times$ Vapour density)
Volatile chloride method	Molecular mass of volatile chloride, $\text{MCl}_x = \text{Eq. mass of M} \times \text{Valency of M} + 35.5x$
	$x = \frac{2 \times \text{Vapour density}}{E + 35.5}$
	Atomic mass of M = Eq. mass of M \times Valency of M

(3) Molecular mass

$$\text{Molecular mass (M)} = \frac{\text{Mass of the molecule of the substance}}{\frac{1}{12} \text{th mass of one atom of carbon-12}}$$

○ Methods of determining molecular mass

Method	Formulae
Vapour density method	Mol. mass = 2 × Vapour density
Diffusion method	$\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{2 \times d_2}{2 \times d_1}} = \sqrt{\frac{M_2}{M_1}}$
Colligative property method	$\Delta T_b = i K_b \times \frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})}$ $\Delta T_f = i K_f \times \frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})}$ $\pi = i \frac{w}{M} \frac{RT}{V}$

(4) Mole concept

(5) Stoichiometry○ **Limiting reagent**

The reactions in which more than one reactants are reacting and if they are not present in the same molar ratio as the balanced equation requires, then one has to find out the limiting reagent *i.e.*, the reagent which is completely consumed in the reaction.

○ **Percentage Composition (by mass)**

% Mass of an element =

(Mass of that element in the compound / Mass of the compound) × 100

○ **Percentage Yield**

Percentage yield of product

$$= \frac{\text{Actual yield}}{\text{Theoretical maximum yield}} \times 100$$

○ **Empirical Formula and Molecular Formula**

An empirical formula represents the simplest whole number ratio of various atoms present in a compound whereas the molecular formula shows the exact number of different types of atoms present in a molecule of a compound.

(6) Reactions in Solutions**(I) In percentage**

(A) Mass percentage $\left(\frac{w_2}{W} \% \right)$:

○ Mass percentage = $\frac{\text{Mass of solute}(w_2)}{\text{Mass of solution}(W)} \times 100$

(B) Volume percent $\left(\frac{v_2}{V} \% \right)$:

○ Volume percent = $\frac{\text{Volume of solute}(v_2)}{\text{Volume of solution}(V)} \times 100$

(C) Mass/Volume percent $\left(\frac{w_2}{V} \% \right)$:

○ Mass/Volume percent = $\frac{\text{Mass of solute}(w_2)}{\text{Volume of solution}} \times 100$

(II) Mole fraction (x) :

○ $X_{\text{solute}} = \frac{\text{Number of moles of solute}(n_2)}{\text{Total moles present in solution}}$

$$= \frac{n_2}{n_1 + n_2}$$

(III) Molarity (M):

$$M = \frac{n_2 \times 1000}{V_{(\text{mL})}}$$

$$M = \frac{w_2}{(MW_2)(V_{(\text{L})})} = \frac{W_2 \times 1000}{(MW_2)(V_{(\text{mL})})}$$

(IV) Molality (m):

$$m = \frac{w_2}{(MW_2)(w_1(\text{kg}))} = \frac{w_2 \times 1000}{(MW_2)(w_1(\text{g}))}$$

(V) Normality (N):

$$N = \frac{E_2 \times 1000}{V_{(\text{mL})}}$$

$$N = \frac{w_2}{(EW_2)(V_{(\text{L})})} = \frac{w_2 \times 1000}{(EW_2)(V_{(\text{mL})})}$$

○ **Dilution formula: $N_1V_1 = N_2V_2$**

○ $N_{\text{Mixture}} = \frac{N_1V_1 + N_2V_2}{V_1 + V_2}$

(VIII) Parts per million (PPM):

$$\text{PPM} = \frac{\text{No. of parts of the component}}{\text{Total no. of parts of the solution}} \times 10^6$$

(7) Relation between various concentration terms**(I) Molarity and Molefraction**

$$M = \frac{(x_2)(1000)(d_{(\text{g/mL})})}{x_1(MW_1) + (x_2)(MW_2)}$$

(II) Molarity and Mass percentage ($\chi\%$)

$$M = \frac{(\chi\%)(d_{(\text{g/mL})})(10)}{MW_2}$$

(III) Normality and Molarity

$$N = (M)(\chi\text{-factor})$$

(IV) Molarity and molality

$$\frac{1}{m} = \frac{d_{(\text{g/mL})}}{M} - \frac{MW_2}{1000}$$

2. STRUCTURE OF ATOM

(1) Subatomic particles

	Electron	Proton	Neutron
Mass in kg	9.109×10^{-31}	1.673×10^{-27}	1.675×10^{-27}
Actual charge	1.602×10^{-19}	1.602×10^{-19}	0

(2) Electromagnetic spectrum

Name of region	Gamma radiation	X-ray radiation	UV radiation	Visible radiation	IR radiation	Microwave radiation	Radio-frequency radiation
Wave length	< 10 pm	10pm -10nm	10nm-400nm	400nm -750nm	750nm -1nm	10mm -10 nm	10cm -10km

(3) Black Body

Ideal body which emits and absorbs radiations of all frequencies. Radiation emitted by such a body is called **Black body radiation**.

- The **energy (E) of a quantum** of radiation is proportional to its frequency (ν) and is expressed by equation

$$E = h\nu \quad \text{or} \quad E = hc / \lambda$$

'h' is known as **Planck's constant**.

(4) Photoelectric effect

$$\text{K.E of ejected electron} = \frac{1}{2}m_e V^2 = h\nu - h\nu_0$$

(5) Hydrogen spectrum

- The **wavelength or wave number** of various lines in the visible region can be expressed by **Rydberg's equation**.

$$\bar{\nu} = \frac{1}{\lambda} = R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

○ Different Series of hydrogen spectrum

Name of series	n_1	n_2	Spectral region
Lyman series	1	2, 3, 4, 5..	Ultraviolet
Balmer series	2	3, 4, 5, 6..	Visible
Paschen series	3	4, 5, 6, 7..	Near infrared
Brackett series	4	5, 6, 7, 8..	Infrared
Pfund series	5	6, 7, 8, 9..	Far infrared

(6) Bohr's theory

- Electrons can revolve only in those stationary orbits in which their angular momentum is equal to integral multiple of $h/2\pi$

$$mvr = n \frac{h}{2\pi}$$

- Radius of Bohr's orbit $r = \frac{n^2 h^2}{4\pi^2 m Ze^2}$
- Expression for the energy of Bohr's orbit

$$E = \frac{-2\pi^2 m Z^2 e^4}{n^2 h^2}$$

- Velocity of electron (V) in hydrogen atom

$$V = \frac{2\pi Ze^2}{nh} = \frac{2.188 \times 10^8}{n} \text{ cm/sec}$$

(7) de-Broglie's equation

$$\text{de-Broglie's equation is } \lambda = \frac{h}{mv} = \frac{h}{p}$$

- *An electron wave to be in phase, the circumference of the Bohr's orbit should be an integral multiple of the wavelength of the electron wave.*

$$n\lambda = 2\pi r$$

(8) Heisenberg's uncertainty principle

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x \cdot m\Delta v \geq \frac{h}{4\pi}$$

(9) Quantum numbers**(I) Principal quantum number (n)**

- The values of $n=1, 2, 3, 4$ or K, L, M, N respectively
- The maximum number of electrons in an orbit $=2n^2$

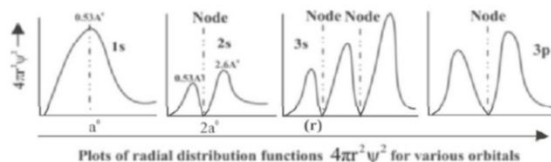
(II) Azimuthal quantum number (l)

- The values of l represents various subshells. When $l=0, 1, 2, 3$ etc they are called as s, p, d, f sub-shells respectively.
- Angular momentum of the electron in an orbital

$$= \frac{h}{2\pi} \sqrt{l(l+1)} = \hbar \sqrt{l(l+1)} \quad \left(\hbar = \frac{h}{2\pi} \right)$$

(III) Magnetic quantum number (m)

- The values of $m = +1, 0, -1$
- The total m values $= 2l + 1$

(IV) Spin quantum number (s)**(10) Filling of electrons in Orbitals of an Atom****(I) Aufbau principle****(II) Pauli's exclusion principle**

- (i) No two electrons in the same atom can have the same values for all the four quantum numbers.

(III) Hund's rule**3.CLASSIFICATION OF ELEMENTS & PERIODICITY IN PROPERTIES****(1) Classification based on electronic configuration****(I) s-Block elements:**

- The elements of the periodic table in which the last electron enters in s-orbital, are called s-block elements.
- GEC (General Electronic Configuration) is ns^1 and ns^2 indicating that s-block has only two groups (1 & 2 or IA & IIA).

(II) p-Block elements:

- The elements in periodic table in which the last electron enters in p-orbital, are called p-block elements.
- GEC is $ns^2 np^{1-6}$ indicating that p-block has 6 groups (13 to 18 or IIIA to VIIA & Zero)
- p-Block constitutes all non-Metals (Except Hydrogen) and also contains few metals and metalloids.

(III) d-Block elements:

- The elements in periodic table in which the last electron enters in penultimate shell or $(n-1)d$ - orbitals are called d-block elements.

- GEC of these elements is $(n-1)d^{1-10} ns^{0/1/2}$ indicating that d-block has 10 groups.

- There are four series viz., 3d-series ($Z=21$ to 30), 4d-series ($Z=39$ to 48), 5d-series ($Z=57, 72$ to 80) and 6d-series ($Z=89, 104$ to 112).
- All the elements are less active metals and form ionic and complex compounds.

(IV) f-Block elements:

- The elements in periodic table in which the last electron enters into antipenultimate shell or $(n-2)f$ - orbitals are called f-block elements.
- GEC of these elements is

$$(n-2)f^{1-14} (n-1)d^{0(or)1} ns^2$$

- Two series of elements : Lanthanides and Actinides. As these elements fall in between 3rd and 4th group transition elements, hence they are named as inner transition elements.

(2) Classification based on properties

Groups	IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	ZERO	
Periods	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1																		He	
2																			Ne
3			Transition Elements																Ar
4		R.E.										Zn	Volatile Metals			R.E.		Kr	
5												Cd						Xe	
6			⁵⁷ La	⁷² Hf								Hg						Rn	
7			⁸⁹ Ac	¹⁰⁴ Rf								Uub						Uuo	
																			Noble Gases

Lanthanides	₅₈ Ce																	₇₁ Lu
Actinides	₉₀ Th																	₁₀₂ Lr

(3) Periodic Properties**(I) Atomic radius****(i) Crystal radius**

Half of the internuclear distance between the adjacent atoms of a solid metallic crystal is called **crystal radius** or **metallic radius**.

(ii) Covalent radius

Half of the internuclear distance of the two atoms held together by a covalent bond is called covalent radius and is generally used to refer radius of non-metals.

(iii) Vander Waal's radius:

It is the Half of the internuclear distance between two atoms of different molecules which are very close to each other in solid state due to vander waals forces is called Van der waals radius.

Variation of atomic radius in Periods

- In a period from left to right, atomic radius decreases.

$$r_n \propto \frac{1}{Z_{\text{eff}}}$$

- In a given period, alkali metal is the largest and halogen is the smallest in size.

Variation of atomic radius in Groups

- In groups from top to bottom, the atomic radius increases.

Reason: $r_n \propto n^2$ (Z_{eff} remaining constant)

Variation of atomic radius in lanthanides

- In Lanthanides (Ce-Lu) the atomic radii decreases steadily. This steady decrease in atomic radii is known as "**Lanthanide Contraction**"

(II) Ionic radius**(III) Ionization energy**

The minimum amount of energy required to remove the most loosely bounded electron from an isolated gaseous atom is known as Ionization energy (I.E.) or Ionization potential (I.P.).

Units : kJ mol⁻¹, kcal mol⁻¹, eV per atom.

- Ionisation energy is endothermic (endoergic) i.e., requires energy hence ΔH is +ve

○ Factors affecting Ionisation Energy

- (a) Atomic size : Varies inversely
- (b) Screening effect : varies inversely
- (c) Nuclear charge : varies directly
- (d) Half filled and completely filled orbital containing elements possesses high ionization energy

○ General Trend: Along period I.E. increases

[with some exception] [$Z_{\text{eff}} \uparrow$]

- Along a group I.E. decrease [Z_{eff} constant, $n \uparrow$]

Exception

- Along a period, half filled and fully filled have higher I.E. e.g. Be > B and N > O.
- along a group, Ga > Al

(IV) Electron affinity (E.A.)

The amount of energy released when an electron is added to an isolated gaseous atom is known as electron affinity.

Units : kJ mol⁻¹, kcal mol⁻¹ and eV per atom.

- Addition of electron results in release of energy i.e., exothermic process in most of the cases but 2nd E.A. is always energy required process i.e.,

endothermic process. The sum of EA_1 & EA_2 is energy required.

○ **Factors affecting Electron Affinity**

- (a) Atomic size : varies inversely
- (b) Nuclear charge : varies directly
- (c) Half filled and completely filled electronic configuration containing elements.

○ **General Trend:** Along a period, electron affinity increases [with exception] as Z_{eff} Increases. Along a group, electron affinity decreases after 3rd period.

(V) **Electronegativity (E.N.)**

The tendency of an atom in a compound to attract a pair of bonded electrons towards itself is known as electronegativity of the atom.

Mulliken's scale :

$$\text{Electronegativity} = \frac{\text{Ionisation potential} + \text{Electron affinity}}{2}$$

○ **Allred-Rochow scale :**

$$\chi = \frac{0.359 Z}{r^2} + 0.744$$

where Z is the effective nuclear charge and r is the covalent radius of the atom in Å.

○ **Pauling scale :**

$$\chi_A - \chi_B = 0.208 \sqrt{\Delta E} \text{ where } \chi_A \text{ and}$$

χ_B are electronegativities of the atoms A and B respectively,

$$\Delta E = \text{Actual bond energy} - \sqrt{(E_{A-A} \times E_{B-B})}$$

Importance of electronegativity :

○ Percentage ionic character may be calculated by **Henny Smith equation, Percentage of ionic character**

$$= 16 | \chi_A - \chi_B | + 3.5 (\chi_A - \chi_B)^2$$

where χ_A and χ_B represents electronegativity of bonded atoms A and B

○ $(X_O - X_A)$ difference predicts the nature of the oxides formed by the element A. X_O is the electronegativity of oxygen.

$X_O - X_A$ is large, the oxide shows basic

nature, (e.g., Na_2O) is small, the oxide shows acidic nature, (e.g., SO_2).

(VI) **Valency or Oxidation state**

The valence is the most characteristic property of the elements and can be understood in terms of their electronic configurations.

Group	IA	IIA	IIIA	IVA	VA	VIA	VIIA	Zero
Number of valence electron	1	2	3	4	5	6	7	8
Valence	1	2	3	4	3,5	2,6	1,7	0,8

(VII) **Metallic and non-metallic character**

○ The tendency of an element to lose electrons and form cations is referred as Electropositive character or Metallic character. Metal has low electronegativity, low IE and high Electropositivity.

Eg: The groups IA and IIA elements have strong metallic nature.

Metals are solids at room temperature except mercury(Hg). Ga, Cs have very low melting points 303K and 302K respectively hence they exists as liquids at room temperature.

○ The tendency of an element to accept electrons to form an anion is called its non-metallic or electronegative character. Non metal has high electron affinity (or high electronegativity) have higher tendency to gain electrons.

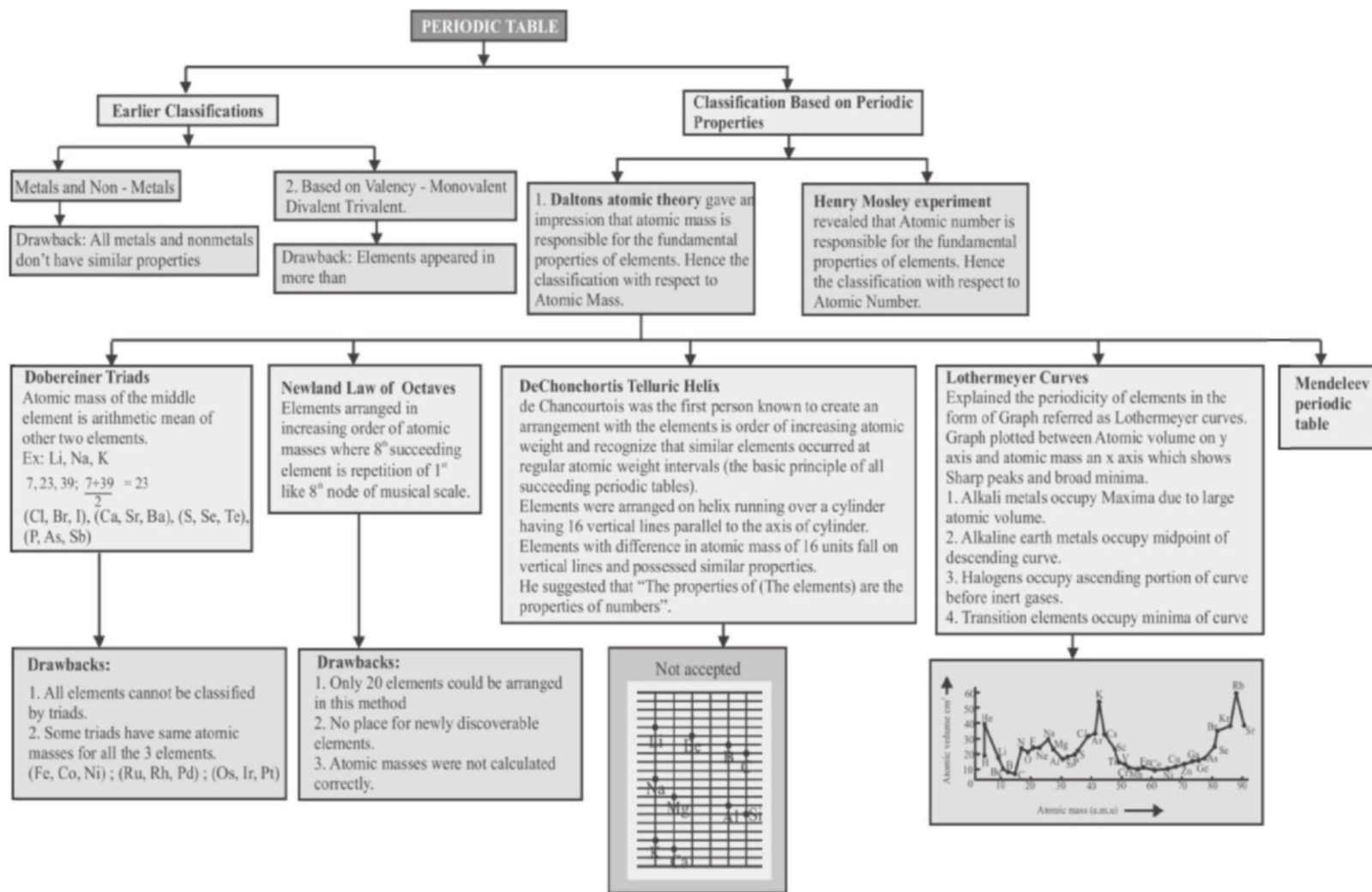
Eg: Group VIA and VIIA elements have strong non-metallic nature.

○ Non-metals are usually solids or gases at room temperature {Except Bromine (liquid)} with low melting and boiling points. (Boron and Carbon are exceptions which have high MP and BP)

(4) **Diagonal Relationship**

In the periodic table the first element of a group has similar properties with the second element of the next group. This is called diagonal relationship. The diagonal relationship disappears after IVA group.

	IA	IIA	IIIA	IVA
2nd Period	${}_3\text{Li}$	${}_4\text{Be}$	${}_5\text{B}$	${}_6\text{C}$
3rd Period	${}_{11}\text{Na}$	${}_{12}\text{Mg}$	${}_{13}\text{Al}$	${}_{14}\text{Si}$



4. CHEMICAL BONDING & MOLECULAR STRUCTURE

- “The attractive force that holds two or more constituent atoms (or) oppositely charged ions together is called Chemical Bond”.
- Formal charge on an atom can be assigned by using the relation

$$Q_f = [N_A - N_M] = [N_A - N_{LP} - (1/2)N_{BP}]$$

(1) Ionic or Electrovalent Bond

(I) Factors influencing magnitude of Lattice Enthalpy are as follows:

(i) Size of ions : $L.E \propto \frac{1}{r^+ \text{ or } r^-}$

(ii) Charge on ions :

$L.E \propto \text{Magnitude of Charge}$

L.E can be calculated indirectly by **Born-Haber Cycle**.

(II) Conditions for ionic bonding Born – Haber equation :

$$\text{Total } \Delta H = \underbrace{S.E. + I.P. + D/2}_{\text{Energy absorbed}} + \underbrace{E.A. + L.E.}_{\text{Energy released}}, \quad L.E = \Delta H - (S.E. + I.P. + D/2 + E.A.)$$

(III) Polarizing Power and Polarizability - Fajan's Rules

Although in an ionic compound, the bond is considered to be 100% ionic, actually it has some covalent character.

- **Polarizing Power:** The power of an ion to distort the other ion. Small size and high magnitude of positive charge has greater polarizing power.

E.g: $\text{Li}^+ > \text{Na}^+ > \text{K}^+ > \text{Rb}^+ > \text{Cs}^+$ and $\text{Na}^+ < \text{Mg}^{2+} < \text{Al}^{3+}$

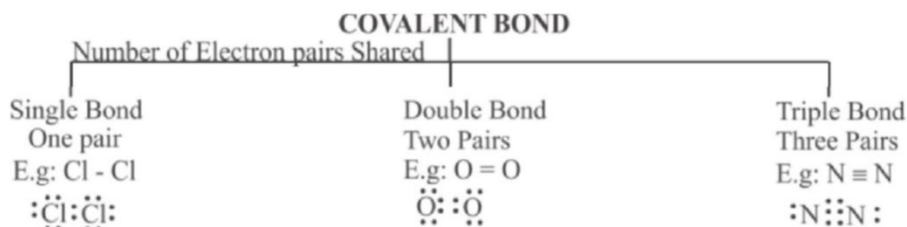
- **Polarizability:** The ease with which an ion get distorted. Larger size and high magnitude of negative charge has greater polarizability. The polarizability of a negative ion is greater than that of a positive ion since the electrons are less firmly bound in negative ion.

E.g: $\text{F}^- < \text{Cl}^- < \text{Br}^- < \text{I}^-$

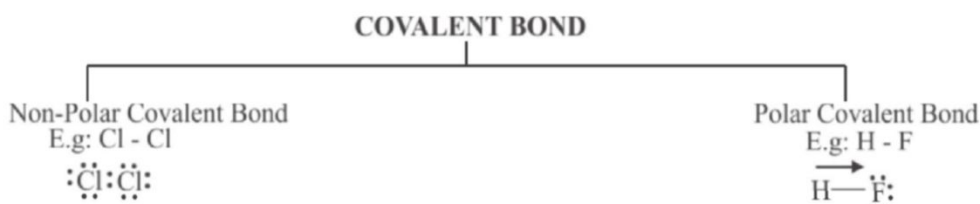
$\text{Cl}^- < \text{S}^{2-} < \text{P}^{3-}$

S.No.	Conditions for Ionic Bond	Conditions against Ionic Bond
1.	Large Cation	Small Cation favours Covalency
Ionic Nature: $\text{BeCl}_2 < \text{MgCl}_2 < \text{CaCl}_2 < \text{SrCl}_2 < \text{BaCl}_2$		
2.	Small Anion	Large Anion favours Covalency
Ionic Nature: $\text{CaF}_2 > \text{CaCl}_2 > \text{CaBr}_2 > \text{CaI}_2$		
3.	Low Magnitude of charge on ions	High Magnitude of charge of ions favours Covalency
Ionic Nature: 1) $\text{NaCl} > \text{MgCl}_2 > \text{AlCl}_3$ 2) $\text{PbCl}_2 > \text{PbCl}_4$ 3) $\text{NaCl} > \text{Na}_2\text{S} > \text{Na}_3\text{P}$		
4.	Ions with inert gas configuration An inert gas configuration is most effective at shielding the nuclear charge. $\text{Na}^+, \text{K}^+, \text{Rb}^+$	Ions with pseudo inert gas Configuration Ions without inert gas configuration has high charges at their surfaces and thus highly polarizing which favours Covalency. $\text{Cu}^+, \text{Zn}^{2+}, \text{Ag}^+, \text{Cd}^{2+}, \text{Au}^+, \text{Hg}^{2+}$

(2) Covalent Bond



Ability to attract shared pair of electrons based on Electronegativity difference



(3) Co-ordinate bond

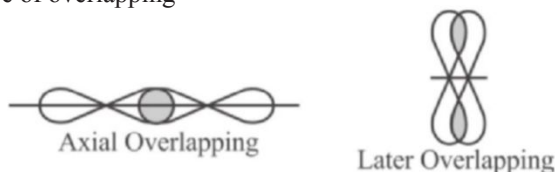
- It involves one sided sharing of an electrons pair between two atoms or groups or molecules in order to acquire the nearest noble gas configuration.
- Atom or molecule having electron pair available for co-ordinate are also known as **Lewis base or ligands**. The others having tendency to accept electron pair are called **Lewis acids**.

(4) Valence Shell Electron Pair Repulsion Theory (VSEPR Theory)

- The shape of a molecule depends upon the number of valence shell electron pairs (bonded or non bonded) around the central atom.
- The repulsive interaction of electron pairs decrease in the order:
Lone pair (lp) – Lone pair (lp) > Lone pair (lp) – Bond pair (bp) > Bond pair (bp) – Bond pair (bp).
- The magnitude of repulsions between bp's of electrons depends on the electronegativity difference between the central atom and the other atoms.
 Number of bond pairs = Number of elements surrounded by central atom.
 Number of lone pairs = $1/2$ [Number of valence electrons of the central atom - number of bonds between central atom and surrounding atom]

(5) Valence bond theory (VBT)

- Covalent bond is formed by the overlapping of two atomic orbitals having unpaired electrons belonging to two same kind or different kind of atoms having opposite spins (antiparallel).
- The greater the extent of overlapping, the stronger is the bond formed.
Extent of overlapping \propto strength of chemical bond
- Nature of overlapping –



- Two types of bonds are formed on account of overlapping.
 - (I) **Sigma (σ) bond** - Bond formed by the end to end overlapping of atomic orbitals along the inter nuclear axis.
 - (II) **Pi (π) bond** - Covalent bond formed by the side wise (or lateral) overlapping of half-filled atomic orbitals of bonding atoms.

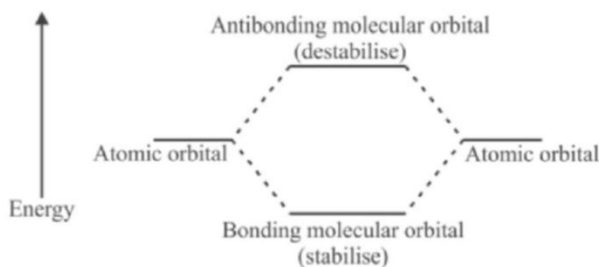
(6) Hybridisation

Geometry	Hybridisation of central atom	Example
Linear	sp	$\dot{\text{C}}\text{O}_2, \dot{\text{Be}}\text{Cl}_2, \dot{\text{Hg}}\text{Cl}_2, \dot{\text{C}}\text{H} \equiv \dot{\text{C}}\text{H}, \text{H}\dot{\text{C}}\text{N}, [\text{Ag}(\text{NH}_3)_2]^+$
Trigonal	sp ²	$\dot{\text{B}}\text{F}_3, \dot{\text{S}}\text{O}_3, \dot{\text{C}}\text{H}_2 = \dot{\text{C}}\text{H}_2, \text{R} - \dot{\text{C}} - \text{R}$
Tetrahedral	sp ³	$\dot{\text{C}}\text{H}_4, \dot{\text{C}}\text{Cl}_4, \dot{\text{N}}\text{H}_3, \text{H}_2\dot{\text{O}}, \dot{\text{C}}\text{H}_3\dot{\text{O}}\text{H}, \text{R}\dot{\text{N}}\text{H}_2, \dot{\text{Ni}}(\text{CO})_4, \text{R}\dot{\text{O}}\text{R}, [\text{Zn}(\text{NH}_3)_4]^{2+}$
Square planar	dsp ²	$\dot{\text{Cu}}(\text{CN})_4^{2-}, [\dot{\text{Ni}}(\text{CN})_4]^{2-}, [\text{Cu}(\text{NH}_3)_4]^{2+}$
Trigonal bipyramidal	sp ³ d	$\dot{\text{P}}\text{Cl}_5, \dot{\text{S}}\text{F}_6, \dot{\text{I}}\text{Cl}_3, \dot{\text{Fe}}(\text{CO})_5, \dot{\text{Xe}}\text{F}_2$
Octahedral	sp ³ d ²	$\dot{\text{S}}\text{F}_6$
Pentagonal bipyramidal	sp ³ d ³	$\dot{\text{I}}\text{F}_7$

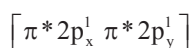
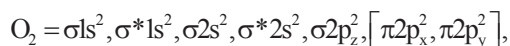
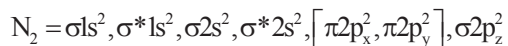
‘ . ’ indicates the central atom.

(7) Molecular orbital theory

- In the molecular orbital theory, the valence electrons are associated with all the nuclei of the molecule. In a molecule, electrons are placed in energy levels called ‘molecular orbitals’. They are obtained as a linear combination of atomic orbitals.
- **Formation of molecular orbitals**



- The electronic configuration and the bond order in case of simple diatomic molecules can be obtained by filling the molecular orbitals according to Aufbau principle and Hunds rule etc.



- **Bond Order:**

$$\text{Bond order} = \frac{1}{2} [\text{Number of electrons in BMO} - \text{Number of electrons in ABMO}]$$

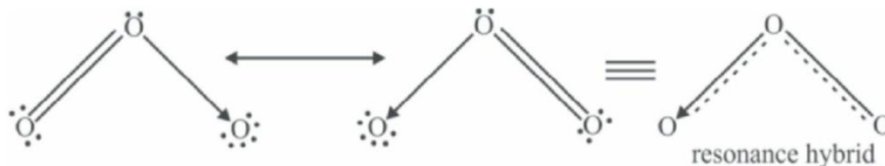
Stability of Molecules

- $N_b > N_a$, then bond order is +ve, this shows stable bond formation
- $N_b < N_a$ or $N_b = N_a$, then bond order is +ve; this shows stable bond formation
- A fractional bond order suggests that bond formed is less stable, however, molecule exists.

(8) Resonance

Resonance is a phenomenon in which a chemical species actual structure is assumed to be in between of all the contributing structures where none of the structure is capable of explaining all the properties satisfactorily.

E.g: Ozone

**(9) Dipole Moment (μ)**

- "The product of the magnitude of charge on any of the atom and the distance between the atoms is defined as dipole moment. It is represented by μ ".

$$\mu = \frac{e}{\text{Charge in esu}} \times \frac{d}{\text{Distance in } \text{\AA}^0}$$

- The unit of μ = Debye (D) = 10^{-18} esu-cm.

- **Net Dipole moment of a molecule is calculated as**

(I) For more than one similar dipoles or polar bonds

$$\mu = 2 \times \text{Bond moment} \times \cos \frac{\theta}{2}$$

(II) For more than one different dipoles or polar bonds

$$\mu = \sqrt{\mu_1^2 + \mu_2^2 + 2\mu_1\mu_2 \cos \theta}$$

Applications of dipole moment

(I) In determining the polarity of bonds:

(II) In the calculation of % ionic character:

% ionic character =

Observed dipole moment

Dipole moment considering 100% ionic character $\times 100$

(III) Symmetry of molecule :

(A) A symmetrical molecule is non-polar even though it contains polar bonds.

E.g: CO_2 , BF_3 , CH_4 , CCl_4 etc.

(B) If the molecule show net dipole moment then the molecule is not symmetrical.

E.g: Water ($\mu = 1.84\text{D}$) and ammonia ($\mu = 1.49\text{D}$).

(10) Hydrogen Bonding

- Hydrogen bond is a weak electrostatic force present between partially positive charged hydrogen atom of a polar molecule and a highly electronegative atom carrying partial negative charge of the same molecule (or) in a different molecule.
- Hydrogen bonds are linear or slightly bent maximising attraction between H and Y and minimising repulsion between X and Y. Angle (α) between H and Y-Z bond, varies between 100° to 140° .

○ Types of hydrogen bonding

(I) *Intermolecular hydrogen bonding:*

Hydrogen bond formed between different polar molecules is known as **intermolecular hydrogen bond**. This type of bonding is observed in different molecules of the same or different substances.

E.g: Ammonia, water, HF etc.

(II) *Intramolecular hydrogen bonding:* Hydrogen bond formed between hydrogen and an electronegative element both present in the same molecule. This type of bonding is generally observed in organic compounds.

Eg: o-nitrophenol, salicylaldehyde etc.

5. STATES OF MATTER

(1) Gas laws

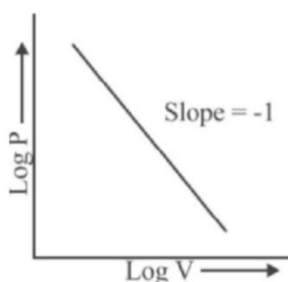
(I) Boyle's Law

"At constant temperature, the Pressure of a fixed amount of a gas is inversely proportional to its Volume."

$$P \propto \frac{1}{V} \quad (T, n \text{ are constant})$$

$$P = \frac{k}{V} \text{ or } PV = k \quad P_1 V_1 = P_2 V_2$$

$$\log P = (-1) \log V + \text{Constant}$$



(II) Charles' law

$$V \propto T \quad (\text{if } P \text{ and } n \text{ are kept constant})$$

$$V = kT$$

(III) Gay-Lussac's law

$$P \propto T \quad (\text{If Volume and number of moles are kept constant})$$

(IV) Avogadro's law

$$v \propto n \quad (T \text{ and } P \text{ are constant}).$$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

(V) Ideal gas equation

$$PV = nRT$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$PM = dRT \quad (\text{or})$$

(VI) Dalton's law of partial pressures

"The total pressure of a mixture of non-reacting gases is equal to the sum of their partial pressures of component gases".

$$P_T = P_1 + P_2 + \dots + P_n$$

$$p_1 = X_1 P_T$$

$$P_{\text{dry gas}} = P_{\text{moist gas}} - \text{Aqueous Tension}$$

(VII) Graham's law of diffusion

$$\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{VD_2}{VD_1}} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{r_1}{r_2} = \frac{P_1}{P_2} \sqrt{\frac{M_2}{M_1}} \quad \text{at constant } T \text{ only.}$$

$$\frac{V_1}{t_1} \times \frac{t_2}{V_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{n_1}{t_1} \times \frac{t_2}{n_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{x_1}{t_1} \times \frac{t_2}{x_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$$

(2) Kinetic molecular theory of gases

- There are no attractions (or) repulsions between the gas molecules.
- The Average kinetic energy (E_k) is directly proportional to the absolute temperature of the gas.

$$E_k \propto T$$

$$PV = \frac{1}{3} mnC^2$$

$$E_k = \frac{3}{2} nRT$$

$$\bigcirc C = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3P}{d}}$$

$$= 1.58 \times 10^4 \times \sqrt{\frac{T}{M}} \text{ cm. sec}^{-1}$$

$$= 1.085 \times \text{Average speed}$$

$$\bar{C} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8PV}{\pi M}} = \sqrt{\frac{8P}{\pi d}}$$

$$C_p = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2PV}{M}} = \sqrt{\frac{2P}{d}}$$

$$= 0.8166 \times \text{RMS speed}$$

$$C_p : \bar{C} : C = 1 : 1.128 : 1.224$$

(3) Vander Waal's equation

$$(P + \frac{a}{V^2})(V - nb) = nRT \text{ for 'n' moles of gas}$$

- 'a' is the measure of magnitude of intermolecular forces of attraction 'b' is the measure of excluded volume.

(I) At low pressures

$$PV = RT - \frac{a}{V}$$

(II) At extremely low pressure

$$PV = RT$$

(III) At high pressures

$$PV = RT + Pb$$

(4) Compressibility Factor (Z)

$$Z = \frac{PV_m^{\text{real}}}{nRT}$$

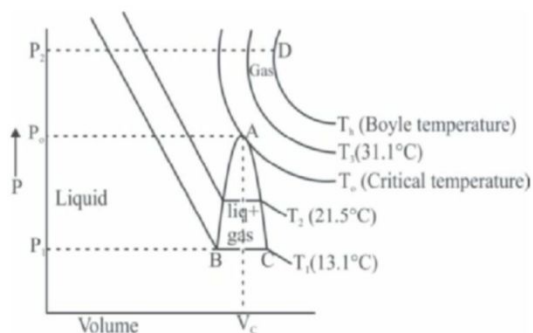
- a) $Z = 1$, the gas is ideal at all temperatures and pressures.
 - b) $Z > 1$, the gas is less compressible than expected from ideal behaviour and shows positive deviation, usually at high P
 - c) $Z < 1$, the gas is more compressible than expected from ideal behaviour and shows negative deviation, usually at low P .
- "Boyle temperature"**

$$T_b = \frac{a}{b}$$

(5) Liquefaction of gases and critical phenomenon

- Principle :

- i) When Temperature of gas is lowered, the volume of gas and also the K.E of molecules decreases. Molecular motion becomes slow, attractive forces increase and the molecules come closer and then gas changes to liquid.
- ii) When Pressure of gas is increased the volume of gas decreases because molecules move closer resulting increased attractive forces where gas is forced to change into liquid.



$$\frac{P_c V_c}{T_c} = \frac{3}{8} R$$

$$P_c = \frac{a}{27b^2}, V_c = 3b, T_c = \frac{8a}{27Rb}$$

(6) Joule-Thomson effect

"Cooling of gas by expansion from high pressure side to low pressure is called "Joule-Thomson effect".

Cooling is due to the fact that internal work is done by the gas in overcoming the attractive forces between the gas molecules.

- Inversion temperature (T_i)

$$= \frac{2a}{Rb}$$

(7) Liquid state

(I) Evaporation

The process of escape of molecules spontaneously from the surface of a liquid is called evaporation.

- The liquids with hydrogen bonding are less volatile & changes with degree of hydrogen bonding.

The rate of evaporation depends inversely on the strength of the intermolecular forces.

(II) Vaporisation

- The conversion of a liquid into its vapour at its boiling point is called vaporisation.

(i) Vapour pressure

The pressure exerted by vapours when there is an equilibrium state between the liquid phase and vapour phase is called equilibrium vapour pressure (or) saturated vapour pressure.

(III) Surface Tension

- The force acting along the surface of a liquid at right angles to any line of 1 unit length is known as surface tension.

- SI unit for surface tension is Nm^{-1} .

Surface tension of liquids decreases with a rise in temperature almost linearly.

Surface tension at T_c for any liquid is zero.

(IV) Viscosity

The measure of resistance to the flow of the layers of liquid.

$$\therefore F = \eta A \cdot \frac{du}{dz}$$

here η - Proportionality Constant (or) Coefficient of Viscosity.

- SI unit for η is $Nm^{-2}s$ or PaS.

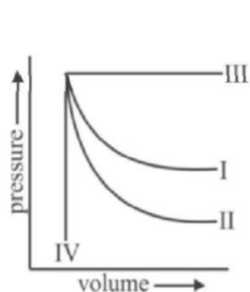
○ Hydrogen bond and van der Waals forces cause high viscosity. Glass is an extremely viscous liquid.

○ As the temperature increases, viscosity decreases since kinetic energy of molecules increases that overcome the intermolecular forces.

6. THERMODYNAMICS

- Thermodynamics is the branch of physical chemistry which deals with the transfer of heat between a chemical system and its surrounding when a change of phase or a chemical reaction takes place within the system. It is also termed as chemical energetics.

○ **Thermodynamic Process**



	Thermodynamics process	Condition	Features
I	Isothermal System kept in contact with a constant temperature bath	System carried out at constant T ($\Delta T = 0$)	Heat is exchanged between system and surroundings
II	Adiabatic System kept in thermally insulated flask	No exchange of heat takes place between system and surroundings ($\Delta q = 0$)	Temperature of system may increase or decrease
III	Isobaric System taking place in an open vessel	System carried out at constant P ($\Delta P = 0$)	Volume changes
IV	Isochoric	System carried out at constant V ($\Delta V = 0$)	Pressure changes

○ **Thermodynamics Properties**

(A) Extensive properties : The properties whose magnitude **depends** upon the quantity of matter present in the system are called extensive properties.

Eg : Mass, volume of a gas, internal energy, enthalpy, entropy, heat capacity, Gibb's energy.

(B) Intensive properties : The properties whose magnitude is **independent** of the quantity of matter present in the system are called intensive properties.

Eg: Pressure, Temperature, Density, Molar properties (such as molar volume, molar entropy, molar heat capacity),

- According to the IUPAC convention:

Heat absorbed in that change = +q

Heat evolved in that change = -q.

Work

(I) *Isothermal Reversible Expansion work of a gases :*

$$w_{\text{rev}} = -2.303nRT \log_{10} \frac{V_2}{V_1}$$

(II) *Isothermal Irreversible Expansion work of a gas*

$$w_{\text{irr}} = -P_2(V_2 - V_1)$$

(III) *Work done in Free Expansion of a gas :*

- Work done during free expansion of a gas is zero since $P_{\text{ext}} = 0$

(1) First Law of Thermodynamics

$$\Delta U = q - w$$

q → Heat absorbed, w → Work done by the system.

(2) Enthalpy of a system

$$H = U + PV$$

$$\Delta H = \Delta U + p\Delta V$$

For any chemical reaction, at any constant temperature, $\Delta H = \Delta U + \Delta n_g RT$

$$\Delta n_g = n_2 - n_1$$

n_2 = total number of moles of gaseous products

n_1 = total number of moles of gaseous reactants

Heat capacity (c)

$$c = \frac{q}{m(T_2 - T_1)} = \frac{q}{m\Delta T}$$

If $m = 1 \text{ g} \Rightarrow c = \text{specific heat}$

If $m = \text{Molar mass} \Rightarrow C = \text{Molar heat capacity}$

Molar heat capacity (C)

$$C_v = \frac{dU}{dT}$$

$$\Delta U = nC_v\Delta T$$

In adiabatic expansion of an ideal gas ($\because q=0$)

$$C_p = \left(\frac{dH}{dT} \right)_p = \frac{q_p}{dT}$$

$$\Delta H = nC_p\Delta T$$

Relation between C_p and C_v for an ideal gas

○ $C_p - C_v = R$

○ $\frac{C_p}{C_v} = \gamma$ (POISSON'S RATIO)

(3) Enthalpy of reaction

- The enthalpy change accompanying a reaction is called the reaction enthalpy ($\Delta_r H$).

In Exothermic reaction : $H_p < H_R \Rightarrow \Delta_r H = -ve$

In Endothermic reaction : $H_p > H_R \Rightarrow \Delta_r H = +ve$

- If temperature range of interest is small or C_p is assumed to be independent of temperature, then

$$\Delta H_2 - \Delta H_1 = \Delta C_p (T_2 - T_1)$$

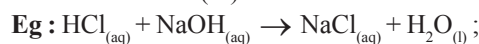
Similarly,

$$\Delta U_2 - \Delta U_1 = \Delta C_v (T_2 - T_1)$$

- Enthalpy change ($\Delta_r H$) of a reaction can be calculated from $\Delta_f H^\circ$ of compounds.

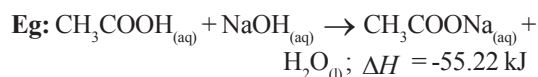
$$\Delta_r H = \sum \Delta_f H^\circ_{\text{Products}} - \sum \Delta_f H^\circ_{\text{Reactants}}$$

- The heat of neutralisation is maximum, when a strong base is neutralised by a strong acid. Heat evolved is 57.3 kJ (or) 13.7 kcal.



$$\Delta H = -57.3 \text{ kJ}$$

- If the acid or base or both are weak, the heat evolved is less than 57.3 kJ or 13.7 kcal



- Enthalpy change ($\Delta_r H$) of a reaction can be calculated from $\Delta_{\text{Bond}} H^\circ$ of bonds in compounds.

$$\Delta_r H = \sum \Delta_{\text{Bond}} H^\circ_{\text{Reactants}} - \sum \Delta_{\text{Bond}} H^\circ_{\text{Products}}$$

(4) Laws of Thermochemistry

(I) *Lavoisier and Laplace law*

The enthalpy of decomposition of a compound is numerically equal to the enthalpy of formation of that compound with opposite sign.

(II) *Hess's law of constant heat summation*

- The heat energy released or absorbed in a process is same whether the process occurs in one step or in several steps.

(5) Entropy (S)

- Entropy is a measure of randomness (or) disorder of the particles of a system.

$$\Delta S = \frac{q_{rev}}{T} = \frac{W_{rev}}{T} = \frac{nRT \log_e \frac{V_2}{V_1}}{T} = nR \log_e \frac{V_2}{V_1}$$

$$= 2.303 nR \log_{10} \frac{V_2}{V_1} = 2.303 nR \log_{10} \frac{P_1}{P_2}$$

(6) Entropy Change during Phase Transformation

$$\Delta S_{fusion} = \frac{q_{rev}}{T} \quad \Delta S = \frac{\Delta H_{fusion}}{\text{melting point}(K)}$$

$$\Delta S_{vapourisation} = \frac{\Delta H_{vapourisation}}{\text{Boiling point}(K)}$$

$$\Delta S_{sub} = S_{vapour} - S_{solid} = \frac{\Delta H_{sub}}{T}$$

Entropy change for ideal gas

- (i) when changes from initial state (1) to state (2)

$$\Delta S = 2.303 nC_v \log \left(\frac{T_2}{T_1} \right) + 2.303 nR \log \left(\frac{V_2}{V_1} \right)$$

(when T and V are variables)

- (ii) Entropy change for isothermal process :

$$\Delta S = 2.303 nR \log \left(\frac{V_2}{V_1} \right)$$

Entropy change for isobaric process (at constant P):

$$\Delta S = 2.303 nC_p \log \left(\frac{T_2}{T_1} \right)$$

(7) Gibb's energy (or) Gibb's function (G)

$$\Delta G = \Delta H - T\Delta S$$

The above equation is referred to as the **Gibb's equation**.

- ΔG gives a criteria for spontaneity at constant pressure and temperature.
- (a) If ΔG is negative (< 0), the process is spontaneous.
- (b) If ΔG is positive (> 0), the process is non spontaneous.

- (c) Standard Gibb's free energy ΔG° of a reaction can be calculated from the following equation.

$$\Delta_r G^\circ = \sum \Delta_f G^\circ(\text{products}) - \sum \Delta_f G^\circ(\text{reactants})$$

○ Gibb's energy change and equilibrium

$$\Delta_r G^\circ = -RT \ln K$$

$$K_{eq} = e^{-\Delta G^\circ/RT} \quad (\text{or}) \quad K_{eq} = 10^{-\frac{\Delta G^\circ}{2.303RT}}$$

○ Free energy change and electrical work done in a cell

$$\Delta G = -nFE$$

○ Effect of enthalpy, entropy and temperature on the spontaneity of a process

NATURE OF REACTION	ΔG	ΔH	ΔS
Spontaneous at all temperature	-	-	+
Non-spontaneous at all temperatures	+	+	-
Spontaneous at low 'T'	-	-	-
Non-spontaneous at low 'T'	+	-	-
Non-spontaneous at low 'T'	+	+	+
Spontaneous at high 'T'	-	+	+

- "The entropy of a pure and perfectly ordered substance is zero at the absolute zero temperature. (-273°C)

$$S_{\lim T \rightarrow 0} = 0$$

**Exercise****Some Basic Concepts of Chemistry**

- Crystals of which pair are isomorphous ?
 (a) $\text{ZnSO}_4, \text{SnSO}_4$ (b) $\text{MgSO}_4, \text{CaSO}_4$
 (c) $\text{ZnSO}_4, \text{MgSO}_4$ (d) $\text{PbSO}_4, \text{NiSO}_4$
- In the final answer of the expression

$$\frac{(29.2 - 20.2)(1.79 \times 10^5)}{1.37}$$

figures is :

- (a) 1 (b) 2 (c) 3 (d) 4

Structure of Atom

3. When beryllium is bombarded with α - particles (Chadwick's experiment) extremely penetrating radiations which cannot be deflected by electric or magnetic field are given out. These are
(a) A beam of protons
(b) Alpha rays
(c) A beam of neutrons
(d) A beam of neutrons and protons
4. Which of the following statements is wrong about cathode rays?
(a) They travel in straight line towards cathode.
(b) They produce heating effect.
(c) They are carrying negative charge.
(d) They produce X - rays when strike with material having high atomic masses.

Classification of Elements & Periodicity in Properties

5. The cause of periodicity of properties is
(a) Increasing atomic radius
(b) Increasing atomic weights
(c) Number of electrons in the valency orbit
(d) The recurrence of similar outer electronic configuration
6. As applied to periodic table, which of the following sets include only magic numbers
(a) 2, 8, 20, 28, 50, 82, 126
(b) 2, 8, 8, 18, 18, 32
(c) 2, 2, 8, 8, 18, 32
(d) 2, 8, 18, 18, 32, 32

Chemical Bonding & Molecular Structure

7. Which of the following has pseudo inert gas configuration?
(a) Na^+ (b) Cu^+ (c) K^+ (d) S^{2-}
8. Lattice energy depends on
(a) Only radius of cation
(b) Only radius of anion
(c) Cation to anion radius ratio
(d) Sum of the radii of cation and anion

States of Matter: Gases & Liquids

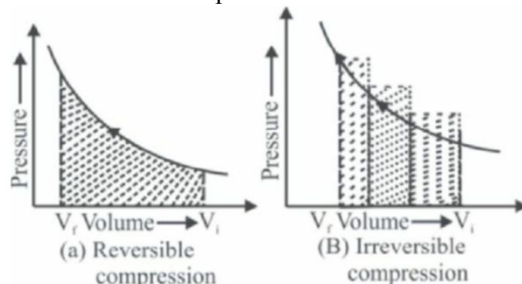
9. The melting point of four substances are given in bracket then the attraction forces in a solid is more in case of
(a) Ice (273 K) (b) NaF (1270 K)
(c) Phosphorous (317K) (d) Naphthalein(353K)
10. If pressure becomes double at the same absolute temperature on 2 L CO_2 , then the volume of CO_2 becomes
(a) 2 L (b) 4 L (c) 25 L (d) 1 L

Thermodynamics

11. The state of a gas can be described by quoting the relationship between
(a) Pressure, volume, temperature
(b) Temperature, amount, pressure
(c) Amount, volume, temperature
(d) Pressure, volume, temperature, amount
12. The pressure-volume work for an ideal gas can be

calculated by using the expression $w = - \int_{V_i}^{V_f} p_{\text{ex}} dV$.

The work can also be calculated from the pV -plot by using the area under the curve within the specified limits. When an ideal gas is compressed (a) reversibly or (b) irreversibly from volume V_i to V_f [Here, P_{ex} at each stage is equal to $v(P_{\text{in}} + dp)$]. Choose the correct option.



- (a) $w(\text{reversible}) = w(\text{irreversible})$
(b) $w(\text{reversible}) < w(\text{irreversible})$
(c) $w(\text{reversible}) > w(\text{irreversible})$
(d) $w(\text{reversible}) = w(\text{irreversible}) + P_{\text{ex}} \Delta V$

ANSWER KEY

1. c 2. b 3. c 4. a 5. d
6. b 7. b 8. d 9. b 10. d
11. d 12. b

CHEMIS TRICKS

By. **A.N.S. SANKARA RAO** (Hyderabad)

Time and tide wait for none. In this competitive world every second, every mark are valuable. Like a super market if all formulae, chemistricks are available at one place, that saves much time and it will be ready reckoner to students. All the lecturers, students (appeared previously for competitive exams) experienced that most of these concepts or chemistricks appeared in NEET, JEE, BITSAT, EAMCET, KCET and other competitive exams. Some shortcuts, chemistricks, memory technics, formulae related to XI class are given in this issue (XII class will appear in March 2019 issue).

ATOMIC STRUCTURE

- Spectrum of electromagnetic radiation.

“**GAXUL VIM T.V., Radio**”

- **Frequency:** **GA**mma rays > **X** rays > **UL**traviolet rays > **V**isible > **I**nfrared rays > **M**icrowave rays > **T.V.** waves > **Radio** waves

$$\bigcirc n \propto P \cdot E \cdot \alpha T \cdot E \propto \frac{1}{K \cdot E} \propto \frac{1}{\text{Velocity}}$$

$$\bigcirc KE : PE : TE = \frac{1}{2} \frac{Ze^2}{r} : \frac{-Ze^2}{r} : -\frac{1}{2} \frac{Ze^2}{r}$$

$$= +\frac{1}{2} : -1 : -\frac{1}{2} = +1 : -2 : -1$$

$$\bigcirc E = \text{Threshold energy} + K \cdot E.$$

$$h\nu = h\nu_0 + K \cdot E.$$

$$\bigcirc E \propto \nu \propto \bar{\nu} \propto \frac{1}{\lambda}$$

$$\bigcirc \frac{1}{R_H} = 912 \text{ \AA} = 91.2 \text{ nm}$$

$$\bigcirc \frac{1}{\lambda} = \bar{\nu} = R_H Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

$$\bigcirc r_n = \frac{n^2 h^2}{4\pi^2 m e^2 Z}$$

$$\bigcirc r_n = 0.529 \frac{n^2}{Z} \text{ \AA}$$

$$\bigcirc E_n = \frac{-2\pi^2 m e^4 Z^2}{n^2 h^2} = -\frac{13.6 Z^2}{n^2} e \cdot V / \text{atom}$$

$$= -\frac{1312 Z^2}{n^2} \text{ kJ / mole}$$

$$= -\frac{313.6 Z^2}{n^2} \text{ kcal / mole}$$

$$\therefore 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$\bigcirc \text{Ionisation enthalpy} = E_\infty - E_n$$

$$= 2.18 \times 10^{-18} \frac{Z^2}{n^2} \text{ J / atom}$$

$$\bigcirc V_n = 2.18 \times 10^8 \frac{Z}{n} \text{ cm / sec}$$

$$\bigcirc \lambda = \frac{h}{p} = \frac{h}{mV} = \frac{h}{\sqrt{2m(K \cdot E)}}$$

$$\bigcirc \Delta x \cdot \Delta V \geq \frac{h}{4\pi m}$$

$$\bigcirc \text{Orbital: } p_x \quad p_y \quad p_z \quad d_{z^2} \quad d_{xy} \quad d_{yz} \quad d_{zx} \quad d_{x^2-y^2}$$

$$m: \quad \pm 1 \quad \pm 1 \quad 0 \quad 0 \quad \pm 2 \quad \pm 1 \quad \pm 1 \quad \pm 2$$

Ram Narayana Sir = 

- No. of Radial Nodes = No. of Nodal Surfaces
= No. of Spherical nodes
= No. of Nodal Regions
= No. of Nodes = $n - l - 1$
- No. of Nodal planes = No. of Angular Nodes = l
- Total No. of Nodes = $n - 1$
- Angular momentum of e^- in an orbital
$$= \frac{h}{2\pi} \sqrt{l(l+1)}$$
- Spin angular momentum of e^- = $\frac{h}{2\pi} \sqrt{S(S+1)}$
- Radial probability = D function
$$= 4\pi r^2 \cdot dr \cdot \Psi^2$$
- No. of peaks = $n - l$
- No. of minimas = $n - l - 1$
- Magnetic moment = $\mu = \sqrt{n(n+2)}$ B.M.
If n = integer then μ = integer + 0.7 or 0.8 or 0.9
 n = no. of unpaired electrons
 $n = \mu - 0.7$ or 0.8 or 0.9

PERIODIC CLASSIFICATION OF ELEMENTS AND PERIODIC PROPERTIES

- Size of iso electronic species $\propto \frac{1}{Z}$
eg. $N^{3-} > O^{2-} > F^- > Ne > Na^+ > Mg^{+2} > Al^{+3}$
- $I \cdot E_1$: $Li < Be > B < C < N > O < F < Ne$;
 $Na < Mg > Al < Si < P > S < Cl < Ar$
- $I \cdot E_2$: $O > F > N > C$; $Li > Ne > B > C > Be$
- Anomalous pairs $Te \& I$; $Ar \& K$; $Co \& Ni$
- $C-C$ bond length:
 $C_2H_6 > diamond > graphite > C_6H_6 > C_2H_4 > C_2H_2$
- $C-O$ bond length : $CO_3^{2-} > CO_2 > CO$
- $O-O$ bond length : $H_2O_2 > O_3 > O_2$
- Bond Enthalpy:
$$\begin{matrix} C \equiv O > N \equiv N > C \equiv N > C \equiv C \\ (1070) & (946) & (891) & 836 \text{ kJ/mol} \end{matrix}$$

- Ionic radius :
 $Mg > Al > Be > B$; $Ac \approx La > Y > Sc$;
 $Hf \approx Zr > Ti$; $S > Cl > O > F$
- Electron gain enthalpy :
 $Cl > S > Si > P > Na > Al > Mg > Ar$;
 $F > O > C > Li > B > N > Be > Ne$;
 $S > O > P > N$; $Si > C > P > N$; $S > Se > Te > O$;
 $Cl > F > Br > I$; $Ne > Ar = Kr > Xe > Rn > He$;
- Electronegativity: $O > Se > S > Te > Po$;
 $N > P > As > Sb = Bi$; $F > O > N = Cl > C > H$;
 $B > Tl > In > Ga > Al$; $C > Si = Ge = Sn = Pb$;
 $Hg > Cd > Zn$

○ $EN \propto \text{oxid. No.} \propto \% \text{ of } s\text{-character} \propto \frac{1}{\text{Atomic size}}$

○ Pauling scale

$$\begin{aligned} X_A - X_B &= 0.1017 \sqrt{\Delta} \quad (\Delta = \text{kJ}) \\ &= 0.208 \sqrt{\Delta} \quad (\Delta = \text{kCal}) \end{aligned}$$

○ Mulliken scale $E.N = \frac{I \cdot E + E \cdot G \cdot E}{2}$

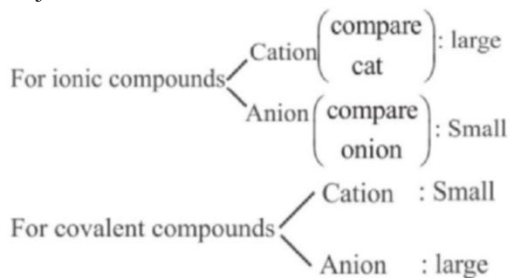
○ Period Number = Valence shell No.

○ Group Number = No. of valence electrons

○ Bridge elements = Mg , Al , Si

CHEMICAL BONDING & MOLECULAR STRUCTURE

○ Fajan's rules:



○ F.C. = $G - L - B$

Where G = Group Number of atom

L = No. of e^- around the atom

B = No. of bonds around the atom

F.C. = Formal Charge

○ **Polarising power** \propto charge on cation \propto charge on anion \propto size of anion \propto Covalent character

$$\alpha \frac{1}{\text{size of cation}} \alpha \frac{1}{\text{Solubility}}$$

- No. of Hybrid orbitals $= \frac{1}{2}(G + M - C)$
[G = group No. of central atom, M = No. of H or halogen atoms, C = Charge ($-ve$ or $+ve$)]
- Dipole moment (μ) $= Q \times d$
- Units : Debye
- $1D = 3.33 \times 10^{-30}$ coulomb cm (S.I)
 $= 10^{-18}$ esu - cm (CGS)
- $Q = 1.6 \times 10^{-19}$ Coulombs
- $\mu = 0$ (trans, Para, Symmetrical, Planar molecules)
- $\mu_{ortho} > \mu_{meta} > \mu_{para}$
- μ : $HF > H_2O > NH_3$ (No of $L \cdot P \cdot S$);
 $HF > HCl > HBr > HI$ (E.N.);
 $CH_3Cl > CH_2Cl_2 > CHCl_3 > CCl_4$;
 $H_2O > NH_3 > NF_3 > CCl_4$
- Lattice energy $\alpha \frac{1}{r_+ + r_-}$
- % of ionic character $= \frac{\mu_{obs}}{\mu_{Cal}} \times 100$
- Repulsion : $L \cdot P - L \cdot P > L \cdot P - B \cdot P > B \cdot P - B \cdot P$.
- Bond strength:
 $sp^3 - sp^3 > sp^2 - sp^2 > sp - sp > p - p > s - p > s - s$
- Dative bonds present in : All complex compounds,
 $N_2O, N_2O_4, N_2O_5, PO_4^{3-}, SO_4^{2-}, SO_2, SO_3, O_3,$
 $B_3N_3H_6, Al_2Cl_6, AlCl_4^-, Cl_2O_6, Cl_2O_7, ClO_2^-,$
 $ClO_3^-, ClO_4^-, H_3O^+, NH_4^+, NO_3^-, BF_4^-, CO,$
 $BF_3 \cdot NH_3, H_2S_2O_8, H_2SO_5, P_4O_{10}, CrO_2Cl_2$
- Bond order of species having $8e^-$ (0), $9e^-$ (0.5),
 $10e^-$ (1.0), $11e^-$ (1.5), $12e^-$ (2.0), $13e^-$ (2.5),
 $14e^-$ (3.0), $15e^-$ (2.5), $16e^-$ (2.0), $17e^-$ (1.5),
 $18e^-$ (1.0), $19e^-$ (0.5), $20e^-$ (0).
- $B \cdot O \cdot \alpha B \cdot E \alpha \text{Stability} \alpha \frac{1}{\text{bond length}}$

If $B \cdot O$ is fractional - paramagnetic

If $B \cdot O$ is integer - Diamagnetic

[Exception $10e^- (B_2)$ & $16e^- (O_2)$]

- Hydrogen bond present between: H & F or O or N
- **Intermolecular** H bonding is present in: Water, ice, NH_3 , HF, phosphoric acid, Acetic acid, 1^0 alcohols, 1^0 & 2^0 amines, carbohydrates, nucleic acids, proteins, para compounds, fatty acids.
- **Intra molecular** hydrogen bonding: Ortho compounds eg: o-chlorophenol, o-Nitrophenol, o-Nitro aniline, o-hydroxy benzoic acid (salicylic acid), o-hydroxy benzaldehyde (salicylaldehyde)
- $B \cdot P \propto M \cdot Wt \cdot \alpha$ normal chain compounds α compounds with H-bonding α Multiple bonds α ionic compounds
- $B \cdot P$: $SnH_4 > GeH_4 > SiH_4 > CH_4$;
 $SbH_3 > NH_3 > AsH_3 > PH_3$;
 $H_2O > H_2Te > H_2Se > H_2S$;
 $HF > HI > HBr > HCl$
- No. of Lone pairs $= G + e^-$ gained or e^- lost - total Valency of surrounded atoms
e.g: No of $L \cdot P \cdot S$ in $XeOF_2$

$$= \frac{8 - (2 + 2)}{2} = 2 L \cdot P \cdot S$$

STATES OF MATTER (GASES & LIQUIDS)

- $S \cdot T \cdot P$: $T = 273K$, $P = 1 \text{ atm}$
(Vol. of 1 Mole gas = 22.4 L)
- $S \cdot A \cdot T \cdot P$ (Standard Ambient Temperature & pressure)
 $T = 298.15K$, $P = 1 \text{ bar}$
(Vol. of 1 Mole gas = 24.79 L)
- $273 \times 0.0821 = 22.4$
- 1 lit - atm = 101.3 joules
- Interaction Energy in

London forces $\propto \frac{1}{r^6}$

Dipole Dipole forces $\propto \frac{1}{r^3}$

Dipole induced dipole forces $\propto \frac{1}{r^6}$

- R value (per K^{-1} mole) $= 1.98 \text{ cal} = 0.082 \text{ lit atm}$
 $= 8.314 J = 8.314 \times 10^7 \text{ erg}$

$$\bigcirc \frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{VD_2}{VD_1}} = \sqrt{\frac{M_2}{M_1}} = \frac{t_2}{t_1} = \frac{V_1}{V_2}$$

- If gases diffuse at different pressures (at same T)

$$\frac{r_1}{r_2} = \frac{P_1}{P_2} \sqrt{\frac{d_2}{d_1}} = \frac{P_1}{P_2} \sqrt{\frac{M_2}{M_1}}$$

- If gases diffuses at different temperatures (at constant P)

$$\frac{r_1}{r_2} = \sqrt{\frac{T_1 d_2}{T_2 d_1}} = \sqrt{\frac{T_1 M_2}{T_2 M_1}}$$

$$\bigcirc d = \frac{PM}{RT}$$

$$\bigcirc \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\bigcirc U_{MP} = \sqrt{\frac{2RT}{M}}$$

$$\bigcirc U_{AV} = \sqrt{\frac{8RT}{\pi M}}$$

$$\bigcirc U_{RMS} = \sqrt{\frac{3RT}{M}}$$

○ YOU _{MAR} i.e $U_{MP} : U_{AV} : U_{RMS} = 0.8 : 0.9 : 1.0$
or $= 1.0 : 1.1 : 1.2$
 $U_{AV} = 0.92 \times U_{RMS}$
 $U_{MP} = 0.81 \times U_{RMS}$

- For any gas $n_{U_{MP}} > n_{U_{AV}} > n_{U_{RMS}}$

$$\bigcirc K \cdot E = \frac{3}{2} kT$$

- Van der waal's equation

at low P & high T : $\frac{PV}{RT} = 1$

at Moderate P : $\frac{PV}{RT} = 1 - \frac{a}{RTV}$ (neglect b)

at Very high P : $\frac{PV}{RT} = 1 + \frac{Pb}{RT}$ (neglect a)

a , b will not depend on Temperature but depends on nature of the gas

$$\bigcirc V_c = 3b; \quad P_c = \frac{a}{27b^2}; \quad T_c = \frac{8a}{27Rb}$$

$$\bigcirc Z = \frac{P_c V_c}{RT_c} = \frac{3}{8} \quad (\text{If } Z=1 \text{ it is ideal gas})$$

- If $Z < 1$ (Show -ve deviation & more compressible)
 $Z > 1$ (Show +ve deviation & less compressible)

STOICHIOMETRY

$$\bigcirc M \cdot F = (E \cdot F)_n$$

$$\bigcirc M \times M.Wt = N \times Eq \cdot Wt$$

- Sum of oxidation states of all atoms in the species = Charge present on the species (If no charge it is = 0)



$$\bigcirc E_{KMnO_4} (\text{Basic Medium}) = M.Wt/1$$

$$\bigcirc E_{KMnO_4} (\text{Neutral Medium}) = M.Wt/3$$

$$\bigcirc E_{KMnO_4} (\text{Acid Medium}) = M.Wt/5$$

$$\bigcirc M = \frac{D \cdot T \cdot P}{G \cdot M \cdot Wt} \quad N = \frac{D \cdot T \cdot P}{G \cdot Eq \cdot Wt}$$

(D = density, T = Ten, P = Percentage)

LEO GER

LEO = Loss of Electrons is Oxidation

GER = Gain of Electrons is Reduction

Oxidising agent undergoes reduction

Reducing agent undergoes Oxidation

THERMODYNAMICS

- $\begin{cases} \text{Intensive property} \\ \text{Independent of quantity of substance} \end{cases}$

$$\bigcirc HE \text{ is } PV \quad H = E + PV$$

$$\Delta H = \Delta E + nR\Delta T$$

- For Isothermal process $\Delta T = 0$, $\Delta U = 0$

$$\text{Adiabatic process } Q = 0$$

$$\text{Cyclic process } \Delta U = 0, \Delta H = 0$$

- ΔE can be represented as ΔU

$$\bigcirc C_p - C_v = R$$

$$\bigcirc C = \frac{q}{dT}$$

○ Work done (W) = $-P\Delta V$

○ Isothermal expansion

$$= W_{rev} = -2.303 nTR \log \frac{V_2}{V_1}$$

○ Isothermal compression

$$= W_{rev} = -2.303 nTR \log \left(\frac{P_1}{P_2} \right)$$

○ Enthalpy is zero for most stable / most abundant allotrope of the element

$$\Delta H_f = (B.E)_{\text{reactants}} - (B.E)_{\text{products}}$$

$$\Delta S = \frac{q_{rev}}{T}$$

$$\Delta G = -2.303RT \log K_C$$

$$= -2.303RT \log K_p$$

○ Criteria spontaneity:

ΔH	ΔS	ΔG	Nature of the reaction
-	-	-	Spontaneous at low T
+	+	+	Non spontaneous at low T
+	+	-	Spontaneous at high T
-	-	+	Non spontaneous at high T
-	+	-	Spontaneous at all T
+	-	+	Non spontaneous at all T

$$\Delta G = -ve, \Delta H = -ve, \Delta S = +ve, K_C > 1$$

$$\Delta G = \Delta H - T\Delta S$$

○ Work done on the system (or) Heat absorbed = $+ve$

○ Work done by the system (or) Heat evolved = $-ve$

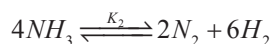
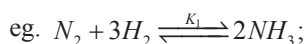
○ If $K_C > Q_C$ (forward reaction)

$$K_C < Q_C \quad (\text{backward reaction})$$

$$K_C = Q_C \quad (\text{equilibrium reaction})$$

CHEMICAL EQUILIBRIUM

$$\text{○ } K_{new} = (K_{old})^{\text{Change}(s)}$$



$$\therefore K_2 = \frac{1}{K_1^2}$$

$$\text{○ } K_p = K_C (RT)^{\Delta n}$$

$$\Delta n = n_{\text{Products (gaseous)}} - n_{\text{reactants (gaseous)}}$$

$$[\text{Solid}] = [\text{Liquid}] = 1$$

IONIC EQUILIBRIUM

$$\text{○ } pH = -\log[H^+] \quad [H^+] = 10^{-pH}$$

○ pH of mixed solution = lowest $pH + 0.3$

(If both pH values < 7)

○ pH of mixed solution = highest $pH - 0.3$

(If both pH values > 7)

$$\text{○ pH of mixed solution} = \frac{pH \text{ of acids} + pH \text{ of base}}{2}$$

(If $pH < 7$ for acid & $pH > 7$ for base)

○ pH of mixed solution having n different pH Values

$$= \text{highest } pH + \log \frac{1}{n}$$

$$\text{○ } pH + pOH = pK_w \text{ (at any T)}$$

$$\text{At } 25^\circ\text{C } pH + pOH = 14$$

$$\text{○ } K_w = K_a \cdot K_b$$

$$\text{○ } [H^+] = c \alpha = \sqrt{K_a \cdot c}$$

$$\text{○ } pH = \frac{1}{2} pK_a - \frac{1}{2} \log C$$

$$\text{○ } [OH^-] = \sqrt{K_b \cdot c} = C\alpha$$

$$\bigcirc \quad pOH = \frac{1}{2} pK_b - \frac{1}{2} \log C$$

$$\bigcirc \quad pH = pK_a + \log \frac{[salt]}{[Acid]}$$

$$\bigcirc \quad pOH = pK_b + \log \frac{[salt]}{[Base]}$$

$$\bigcirc \quad K_h = \frac{K_w}{K_{Weak\ thing}}$$

For salt solution of

W.A & S.B:



Salt undergoes anionic hydrolysis. Nature of solution is basic ($pH > 7$)

$$\rightarrow K_h = \frac{K_w}{K_a}$$

$$\rightarrow pH = 7 + \frac{1}{2} pK_a + \frac{1}{2} \log C$$

S.A & W.B:



Salt undergoes cationic hydrolysis. Nature of solution is acidic ($pH < 7$)

$$\rightarrow K_h = \frac{K_w}{K_b}$$

$$\rightarrow pH = 7 - \frac{1}{2} pK_a - \frac{1}{2} \log C$$

W.A & W.B:



Salt undergoes both cationic & anionic hydrolysis.
 $pH > 7$ or $pH < 7$

Nature of solution may be alkaline or acidic

$$\rightarrow K_h = \frac{K_w}{K_a \cdot K_b}$$

$$\rightarrow pH = 7 + \frac{1}{2} pK_a - \frac{1}{2} pK_b$$

S.A. & S.B.



No hydrolysis. Nature of solution is neutral ($pH = 7$).

SALTS

1. **Normal salts:** Contains neither replaceable H^+ nor OH^-

eg: NaH_2PO_4 , $CaCl_2$, $MgCl_2$, $AlPO_4$, KNO_3 , KCl , $NaCl$, Na_2SO_4

2. **Acidic salts:** Contains replaceable H atoms

eg: $NaHCO_3$, $NaHSO_4$, Na_2HPO_4 , NaH_2PO_4

3. **Basic salts:** Contains replaceable OH group



4. **Mixed salts:** Contains more than one type of cations or anions.

eg: $CaOCl_2$ (contains Cl^- & OCl^-), $NaKSO_4$ (contains Na^+ & K^+)

5. **Double salts:** Contains 2 simple salts

eg: Carnalite - $KCl \cdot MgCl_2 \cdot 6H_2O$

Mohr's salt - $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 24H_2O$

Potash alum - $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

6. **Complex salts:** Contains complex ion (shown in [])

eg: $K_3[Fe(CN)_6]$, $[Cu(NH_3)_4]SO_4$

Acidic Buffer: Mixture of **Weak Acid** & its **Salt** of **Strong Base**

eg: $CH_3COOH + CH_3COONa$,

$NaHCO_3 + Na_2CO_3$, $H_2CO_3 + NaHCO_3$

Basic Buffer: Mixture of **Weak Base** + its **Salt** of **Strong Acid**

eg: $NH_4OH + NH_4Cl$

$$\bigcirc \quad \text{Buffer Capacity}(\phi) = \frac{n}{\text{change in } pH}$$

where n = No. of moles of acid or base added to 1 litre solution.

For a salt M_xN_y

$$K_{SP} = x^x \cdot y^y \cdot S^{x+y} \quad \therefore S = \left(\frac{K_{SP}}{x^x \cdot y^y} \right)^{\frac{1}{x+y}}$$

$$\bigcirc \quad K_{SP} \text{ of } Zr_3(PO_4)_4 = (3S)^3 (4S)^4 = 6912 S^7$$

s-BLOCK ELEMENTS

Density = $Cs > Rb > Na > K > Li$

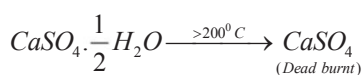
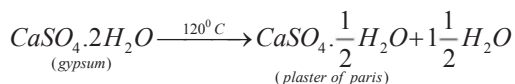
Alkali metal in liquid NH_3 : Mixed conductor
(Both electronic and electrolytic conductors)

In cold condition: **Blue** color & **paramagnetic**

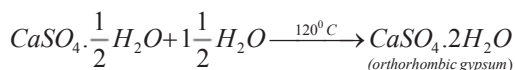
In hot condition: **bronze** & **diamagnetic**

White Metal is alloy of: $Li + Pb$

- LiF least soluble \therefore high lattice enthalpy
- CsI least soluble \therefore low hydration enthalpy
- Ionic/Saline hydrides - *IA, IIA* group elements
- Covalent/Molecular hydrides - 15, 16, 17 group elements
- Non-stoichiometric hydrides - Transition elements (Law of constant composition does not hold good)
- Hydrides not formed by - 7, 8, 9 group elements
- Deliquescent: $LiCl$, $MgCl_2$, $CaCl_2$
- $NaHCO_3$: Antacid & antiseptic
- Na^+ : Oxidation of glucose to produce ATP
- In **sodium pump**: **Na** out, **K** in
- Alkali metal in liquid NH_3 : Mixed conductor
In cold condition: Blue & Paramagnetic colour
In hot condition: Bronze colour & Diamagnetic.
- Milk of Magnesia: suspension of $Mg(OH)_2$ in water
- $Mg(OH)_2$ to $Ba(OH)_2$: Solubility, basic character, thermal stability increases
- Solubility of II group carbonates, sulphates: decrease down the group



Setting stage:



Hardening state:



- Quick lime: CaO

Slaked lime: $Ca(OH)_2$



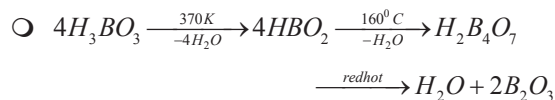
Dead burnt plaster: $CaSO_4$

Gypsum: $CaSO_4 \cdot 2H_2O$

- Ca^{+2} concentration is maintained by: calcitonin, parathyroid hormones

p-BLOCK ELEMENTS

- **Inert pair effect**: Tl^{+1} , Pb^{+2} , Bi^{+3}



- BN has graphite structure.
- Acidic Nature: $BBr_3 > BCl_3 > BF_3$ (due to back bonding)
- B_2H_6 :
e⁻ deficient, 2 B-H-B bonds or 2 bridge bonds, 4 terminal & 2 bridged H atoms, no B-B bonds.
- Acidic oxides: B_2O_3 , CO_2 , SiO_2
- Amphoteric oxides: Al_2O_3 , PbO_2
- Basic oxides: Tl_2O_3
- ZSM-5: Zeolite Socony Mobil-5 used to convert alcohol to gasoline
- Fullerene: 20 Six membered, 12 five membered rings are present, C-C bond lengths: 1.43\AA & 1.38\AA , sp^2 hybridisation.
- SiO_2 does not dissolve in water (due to tetrahedral structure it becomes non-polar), $SiCl_4$ dissolves (due to presence of vacant d -orbitals)
- Dry ice: Solid CO_2 , used as refrigerant
- Calorific values: The great (>) **CaWa Sem producer** carburetted **water** gas > Water gas > **semi** water gas > **producer** gas
- Quartz - Piezo electric material
- Crystalline allotropes of SiO_2 : Quartz, cristobalite, Tridimite.
- **Feldspar** is a zeolite.
- Zeolites are 3D silicates.

ENVIRONMENTAL CHEMISTRY

- Photochemical smog
$$= O_3 + PAN + NO + CH_2 = CHCHO$$
- **BOD** of polluted water ≥ 17 ppm
- During Fluorosis: Hydroxy apatite is converted to fluorapatite
- **Blue baby syndrome**: caused if
 $[NO_3^-] > 50$ ppm parts per million in water
- **Extent of pollution**

$$\alpha B \cdot O \cdot D \alpha C \cdot O \cdot D \alpha \frac{1}{T \cdot L \cdot V} \alpha \frac{1}{D \cdot O}$$

ORGANIC CHEMISTRY

$$\begin{aligned} \bigcirc \text{ \% of C} &= \frac{\text{Wt. of CO}_2}{44} \times \frac{100}{\text{Wt. of O.C.}} \times 12 \\ &= \frac{\text{Wt. of CO}_2}{\text{Wt of O.C.}} \times 27.27 \end{aligned}$$

$$\begin{aligned} \bigcirc \text{ \% of H} &= \frac{\text{Wt. of H}_2\text{O}}{18} \times \frac{100}{\text{Wt. of O.C.}} \times 1 \times 2 \\ &= \frac{\text{Wt. of H}_2\text{O}}{\text{Wt of O.C.}} \times 11.11 \end{aligned}$$

(Duma's method)

$$\begin{aligned} \bigcirc \text{ \% of N} &= \frac{\text{Vol. of N}_2}{22,400} \times \frac{100}{\text{Wt. of O.C.}} \times 28 \\ &= \frac{\text{Vol. of N}_2}{\text{Wt of O.C.}} \times 0.125 \end{aligned}$$

(Kjeldahl's method)

$$\begin{aligned} \bigcirc \text{ \% of N} &= \frac{\text{Wt. of NH}_3}{17} \times \frac{100}{\text{Wt. of O.C.}} \times 14 \\ &= \frac{\text{Wt. of NH}_3}{\text{Wt of O.C.}} \times 82.3 \text{ or} \end{aligned}$$

$$\text{ \% of N} = \frac{1.4 \times 10 \times V}{\text{Wt. of O.C.}}$$

$$\bigcirc \text{ \% of S} = \frac{\text{Wt. of BaSO}_4}{233} \times \frac{100}{\text{Wt. of O.C.}} \times 32$$

$$\bigcirc \text{ \% of Cl} = \frac{\text{Wt. of AgCl}}{143.5} \times \frac{100}{\text{Wt. of O.C.}} \times 35.5$$

$$\bigcirc \text{ \% of Br} = \frac{\text{Wt. of AgBr}}{188} \times \frac{100}{\text{Wt. of O.C.}} \times 80$$

$$\bigcirc \text{ \% of I} = \frac{\text{Wt. of AgI}}{235} \times \frac{100}{\text{Wt. of O.C.}} \times 127$$

$$\bigcirc \text{ \% of P} = \frac{\text{Wt. of Ammo.phos.Molybdate}}{\text{Wt. of O.C.}} \times 1.65$$

$$\text{ \% of P} = \frac{\text{Wt. of Mg}_2\text{P}_2\text{O}_7}{\text{Wt. of O.C.}} \times 28$$

Non benzenoid aromatic compounds:

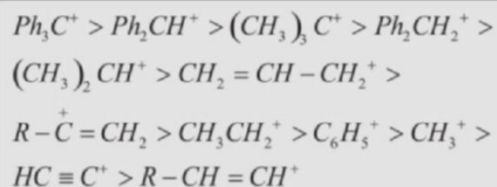
Tropolone, Tropylium cation, cyclopenta dienyl anion

Priority (seniority) order of functional groups:

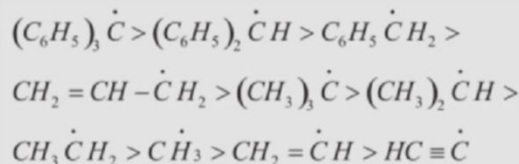
$-\text{COOH} > -\text{SO}_3\text{H} > -\text{COO}^- > -\text{COX} > -\text{CONH}_2 > \\ -\text{CN} > -\text{NC} > -\text{CHO} > -\text{CO} > -\text{OH} > -\text{SH} > \\ -\text{NH}_2 > -\text{O}- > \text{bond} > \equiv \text{bond} > -\text{X} > -\text{NO}_2$

Stability:

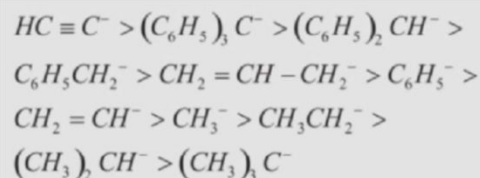
The overall stability of the **carbocations** decreases in the order:



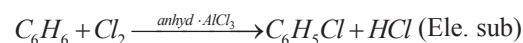
The overall stability of **free radicals** follows the order:



The overall stability of the **carbanions** decreases in the order:

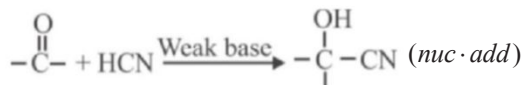
**Carbocation & free radicals:** sp^2 & trigonal planar,

carbanion: sp^3 & pyramidal

Types of reactions:

$CH_3CH=CH_2 + HBr \xrightarrow{\text{peroxide}} CH_3CH_2CH_2Br$
(Anti Markovnikov & free rad. addition)
(**Anti Markovnikov addition is not possible with HCl & HI).

$CH_3CH=CH_2 + HBr \rightarrow CH_3CH(Br)CH_3$
(Markovnikov & Ele. add)



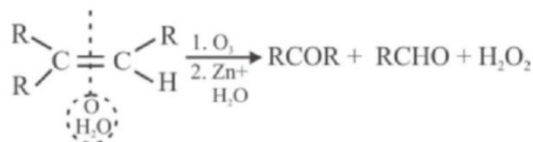
(nuc = nucleophilic, Ele = Electrophilic,
rad = radical, Sub = substitution, add = addition)

- $Fe_4[Fe(CN)_6]_3$ = prussian blue [Iron (III) hexacyano ferrate (II)]
- $Na_2[Fe(CN)_5NO]$ = Sodium Nitro prusside [sodium pentacyanonitrosylFerrate(II)] = gives violet color with S
(Note : Oxi. state of NO = +1)
- H_2NNH_2 , $NaNO_3$, NH_4Cl do not respond Lassaigne's test as C is absent. Diazonium salts do not respond (as they lose N_2 on heating)
- $[Fe(SCN)]^{+2}$ = **Blood red**
- $(NH_4)_3PO_4 \cdot 12MoO_3$ = **Canary yellow**
- Liebig's Method = Estimation of C & H
- Carius Method = Est. of X, S, P
- Kjeldahl's Method is not applicable for

$-\overset{\text{O}}{\underset{|}{\text{N}}}-$, $-\text{NO}_2$, $-\text{N}=\text{N}-$, $-\text{N}=\text{N}-$, pyridine, Quinoline
as N is not converted to $(NH_4)_2SO_4$.

- Alkanes can have **infinite** no. of **conformers**.
- CH_4 can not be prepared by Wurtz reaction & Kolbes electrolysis
- Lindlar's Catalyst (Pd/C/Quinoline or $BaSO_4$) gives **cis** alkenes.
- $Na / Liq \cdot NH_3$ gives **trans** alkenes
- **Dehydrohalogenation & Dehydration (of alcohols):** β - elimination.
(As H is eliminated from β carbon).

○ **Ozonolysis:**



○ **Electrophiles formed in electrophilic**

substitution reaction: nitration ($\overset{+}{N}O_2$),

halogenation ($\overset{+}{X}$), Sulphonation (SO_3),

Alkylation ($\overset{+}{C}H_3$), acylation ($\overset{+}{CO}CH_3$).

- **Avopa:** ring **A**ctivating groups are **O**rtho & **P**ara directing groups ($-R$, $-C_6H_5$, $-X$, $-OH$, $-OR$, $-NH_2$, $-NHR$, $-NR_2$, $-NHCOR$)

- **Meta directing groups:** ring **d**eactivating groups

$-\overset{\text{O}}{\underset{||}{\text{C}}}-$, $-\text{NO}_2$, $-\text{CHO}$, $-\text{COR}$, $-\text{COOH}$, $-\text{COOR}$, $-\text{CONH}_2$, SO_3H , $-\text{CN}$, $-\text{NC}$, $-\text{CF}_3$)

RANK EDGE AKADEMI OF CHEMISTRY

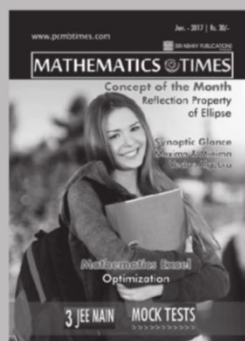
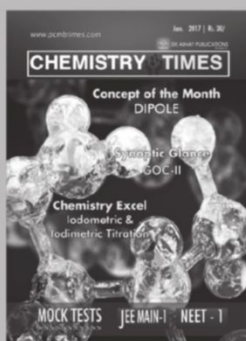
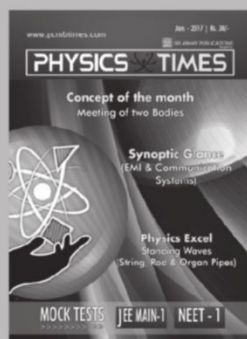
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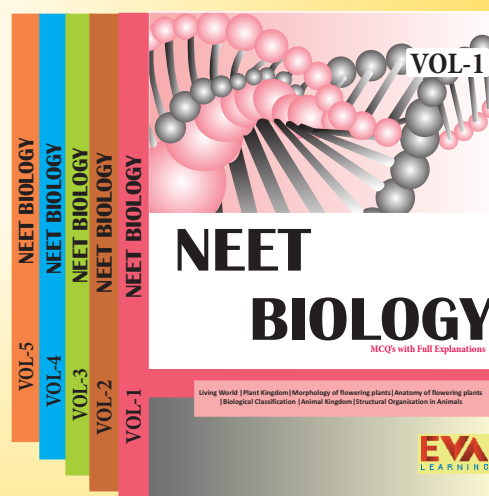
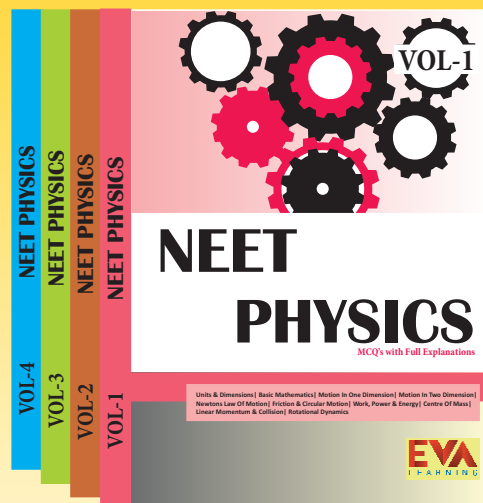
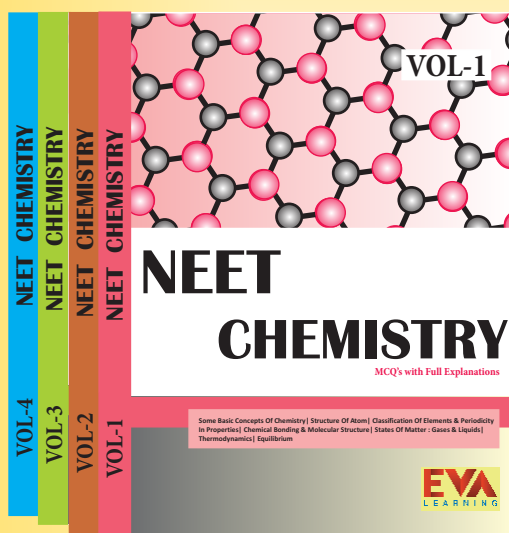
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- Chapter wise theory
- Chapter wise MCQ's with detailed solutions
- Hand picked treasures in MCQ's
- Figure/Graph based questions
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- Assertion & Reason based questions
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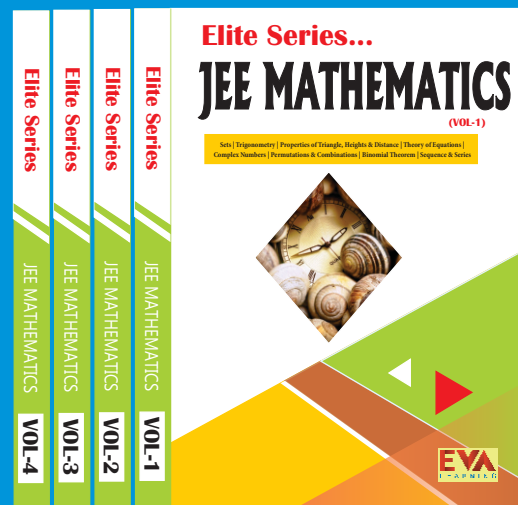
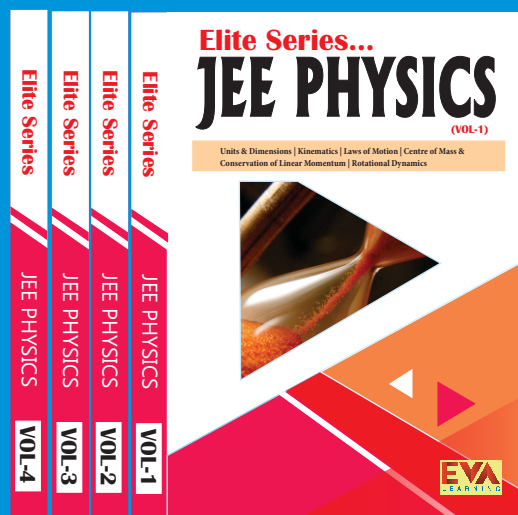
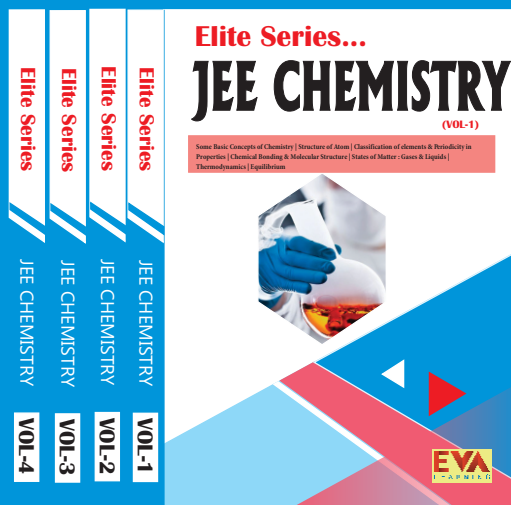


Class XI & XII

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JEE CHEMISTRY

JEE MATHEMATICS



Highlights

- Chapter wise theory
- Chapter wise MCQ's with detailed solutions
- Hand picked treasures in MCQ's
- Graph based questions
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